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THIRTY-SEVENTH ANNUAL REPORT

of

Forage Research

in the

Northeastern United States

1973

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1973
Thirty-Seventh Annual Report
of
Forage Research
in the
Northeastern United States

A Joint Contribution of the
U.S. Regional Pasture Research Laboratory
and the
Agricultural Experiment Stations
of the
Twelve Northeastern States

Participating Agencies
Beltsville Agricultural Research Center,
Chesapeake-Potomac Area, and
North Atlantic Area
of the Northeastern Region
Agricultural Research Service, U.S. Department of Agriculture
and the

Agricultural Experiment Stations of

Connecticut (Storrs)	New York (Cornell)
Delaware	New York (Geneva)
Maine	Pennsylvania
Maryland	Rhode Island
Massachusetts	Vermont
New Hampshire	West Virginia
New Jersey	

* * * * *
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PREFACE

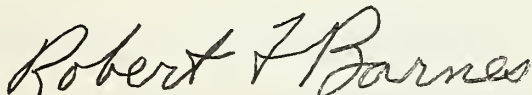
This Annual Report is intended primarily for use by forage research and extension workers in the Northeastern United States. It contains brief reports of research projects carried on at most of the State Agricultural Experiment Stations in the region. It also includes reports from several Regional Research Technical Committees and research personnel of the Northeastern Region, Agricultural Research Service, U.S. Department of Agriculture. Our appreciation is extended to all contributors and to the contact person at each station who coordinated the collection of reports.

Over 100 reports were received which involved more than 130 scientists. The reports are divided topically into various sections. For convenience an author index has been prepared. A roster is included of research and extension workers in the Northeastern United States who devote at least a portion of their time to forage and grassland research or extension activities. Publications appearing since the last report and names of individuals receiving their advanced degrees in 1973 are listed.

We have included a brief description of the U.S. Regional Pasture Research Laboratory, which updates the goals and objectives of the Laboratory and our current research staff assignments.

The role of forage and grassland research in the Northeast must be considered in a new light in today's society. Traditional views and approaches must be reexamined and tested to determine if they can meet the greatly increasing demands for food and fiber in the future. Where these traditional views are found lacking, new methods, new approaches, and new ideas must be formulated through research. It is hoped that this compilation of information on forage and grassland research in the Northeastern United States will be of value in the assessment of research goals and priorities for the future.

We would appreciate your thoughts and suggestions on how we might make this report more accurate and relevant in the future.

A handwritten signature in cursive script that reads "Robert F. Barnes". The signature is written in dark ink and is positioned above the printed name and title.

Robert F. Barnes
Laboratory Director

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Roster of Research and Extension Workers in the Northeastern
United States with Some Forage Crops and Grasslands Orientation

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Connecticut</u>		
Storrs 06268		
Allinson, D. W.	Forage Management	Plant Science
Cowan, W. A.	Animal Nutrition	Animal Industries
Dest, W. M.	Weed Investigations	Plant Science
Griffin, G. F.	Soil Fertility	Plant Science
Peters, R. A.	Weed Investigations	Plant Science
Washko, W. W.	Forage Management	Plant Science
Wengel, R. W.	Soil Physics	Plant Science
 <u>University of Delaware</u>		
Newark 19711		
Crittenden, H. W.	Legume Diseases	Plant Science
Fowler, R. E.	Beef Cattle Nutrition	Animal Science and Agricultural Biochemistry
Haenlein, G. F. W.	Nutritive Evaluation	do.
Jones, E. R.	Forage Management	Dept. of Agriculture Delaware State College Dover, Del. 19901
Mitchell, W. H.	Forage Management	Plant Science
Reitnour, C. M.	Horse Physiology	Animal Science and Agricultural Biochemistry
Svec, L. V.	Physiology	Plant Science
 <u>University of Maine</u>		
Orono 04473		
Apgar, W. P.	Forage Utilization	Animal and Veterinary Sci.
Brown, C. S.	Forage Management	Plant and Soil Sciences
Dickey, H. C.	Forage Preservation	Animal and Veterinary Sci.
Forsythe, H. Y., Jr.	Forage Insects	Entomology
Holyoke, V. H.	Silage Corn Management	Plant and Soil Sciences
Rowe, R. J.	Engineering Harvesting	Agricultural Engineering

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Maryland</u>		
College Park 20742		
Bickley, W. E.	Entomology	Entomology
Bull, L. S.	Dairy Science	Dairy Science
Burt, G. W.	Weed Control	Agronomy
Clark, N. A.	Forage Management	Agronomy
Decker, A. M., Jr.	Forage Management	Agronomy
Harris, W. L.	Agricultural Engineering	Agricultural Engineering
Leffel, E. C.	Animal Science	Animal Science
Morgan, O. D., Jr.	Plant Pathology	Botany
Parochetti, J. V.	Weed Control	Agronomy
Steinhauer, A. L.	Entomology	Entomology
Vandersall, J. H.	Dairy Science	Dairy Science
<u>University of Massachusetts</u>		
Amherst 01002		
Chen, C. S.	Agricultural Engineering	Engineering (Food & Agr.)
Colby, W. G.	Forage Management	Plant and Soil Sciences
Drake, Mack	Forage Management	Plant and Soil Sciences
Fenner, Heinrich	Animal Nutrition	Veterinary & Animal Sci.
Jensen, G. L.	Entomology	Entomology
Vengris, Jonas	Weed Control	Plant and Soil Sciences
Whitney, L. E.	Agricultural Engineering	Engineering (Food & Agr.)
<u>University of New Hampshire</u>		
Durham 03824		
Byers, G. L.	Agricultural Engineering	Water Resources Research Center
Dunn, G. M.	Genetics	Plant Science
Estes, G. O.	Forage Nutrition	Plant Science
Holter, J. B.	Animal Nutrition	Animal Sciences
Koch, D. W.	Forage Plant Physiology	Plant Science
Mitchell, J. R.	Forage Management	Plant Science
O'Connor, J. T.	Animal Science	Animal Sciences
Peirce, L. C.	Genetics and Horticulture Crops	Plant Science
Routley, D. G.	Plant Chemistry	Plant Science

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>Rutgers University, The State</u> <u>University of New Jersey</u> <u>New Brunswick 08903</u>		
Duell, R. W.	Highway Vegetation	Soils and Crops
Evans, J. L.	Nutritional Value	Animal Science
Halisky, P. M.	Plant Pathology	Plant Biology
Ilnicki, R. D.	Weed Control	Soils and Crops
Mears, D. R.	Agricultural Engineering	Engineering
Race, S. R., Jr.	Forage Insects	Entomology and Economic Zoology
Ramage, C. H.	Production Utilization	Animal Science
Singley, M. E.	Engineering, Utilization	Engineering
Sprague, M. A.	Management, Preservation	Soils and Crops
Vander Noot, G. W.	Forage Utilization	Animal Science
<u>Cornell University (New York)</u> <u>Ithaca 14850</u>		
Campbell, J. K.	Agricultural Engineering	Agricultural Engineering
Duke, W. B.	Weed Control	Agronomy
Fick, G. W.	Forage Physiology and Management	Agronomy
Grunes, D. L.	Soils & Plant Nutr.	*U.S. Plant, Soil and Nutrition Laboratory
Gyrisco, G. G.	Entomology	Entomology
Helgesen, R. G.	Entomology	Entomology
Linscott, D. L.	Weed Control	Agronomy
Lowe, C. C.	Genetics and Breeding	Plant Breeding and Biometry
Lucey, R. F.	Forage Management	Agronomy
Millar, R. L.	Plant Pathology	Plant Pathology
Millier, W. F.	Agricultural Engineering	Agricultural Engineering
Murphy, R. P.	Genetics and Breeding	Plant Breeding and Biometry
Pardee, W. D.	Forage Management	do.
Reid, J. T.	Animal Nutrition	Animal Science
Schaaf, H. M.	Genetics and Breeding	*Plant Breeding and Biometry
Seaney, R. R.	Forage Management	Agronomy
Van Soest, P. J.	Animal Nutrition	Animal Science
Wright, M. J.	Forage Management	Agronomy

* USDA-ARS Cooperative appointment.

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>New York State Agricultural Experiment Station</u> Geneva 14456		
Dolan, D. D.	Plant Introduction	Seed & Vegetable Sciences and ARS, USDA
Pfleger, F. L.*	Plant Pathology	do.
Sherring, W. R.	Seed Technologist	Seed & Vegetable Sciences, Cornell University
<u>The Pennsylvania State University</u> University Park 16802		
Ace, D. L.	Dairy Extension	Dairy Science
Adams, R. S.	Dairy Extension	Dairy Science
Bartlett, H. H.	Agricultural Engineering	Agricultural Engineering
Baumgardt, B. R.	Animal Nutrition	Animal Science
Baylor, J. E.	Pasture and Forage Crops (Extension)	Agronomy Extension
Bloom, J. R.	Nematode Control	Plant Pathology
Burdette, L. A.	Animal Nutrition Ext.	Animal Science
Cash, E. H.	Animal Nutrition	Animal Science
Cleveland, R. W.	Genetics and Breeding	Agronomy
Cowan, R. L.	Animal Nutrition	Animal Science
Downs, W. G.	Forage Management	Agronomy (P.O. Rector)
Dum, S. A.	Farm Management Ext.	Economics
Guss, S. B.	Veterinary Sci. Ext.	Veterinary Science
Hartwig, N. L.	Weed Control	Agronomy
Hershberger, T. V.	Animal Nutrition	Animal Science
Hower, A. A., Jr.	Forage Insects	Entomology
Johnson, M. W.	Corn Breeding	Agronomy
Kardos, L. T.	Soil Physics	Agronomy
Kesler, E. M.	Dairy Science	Dairy Science
Kjelgaard, W. L.	Agricultural Engineering	Agricultural Engineering
Knieval, D. P.	Forage Physiology	Agronomy
Kradel, D. C.	Veterinary Medicine	Veterinary Science
Long, T. A.	Animal Nutrition	Animal Science
Lukezic, F. L.	Forage Pathology	Plant Pathology
Marriott, L. F.	Soil Fertility	Agronomy
McKee, G. W.	Ecology, Physiology	Agronomy
Merritt, T. L.	Animal Science	Animal Science
Partenheimer, E. J.	Agricultural Economics	Agricultural Economics and Rural Sociology
Risius, M. L.	Genetics and Breeding	Agronomy
Shenk, J. S.	Forage Grass Breeding	Agronomy
Starling, J. L.	Genetics and Breeding	Agronomy

* F. L. Pfleger is now with Dept. of Plant Pathology, Univ. of Minn.

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>The Pennsylvania State University (con'd.)</u>		
Thomas, W. I.	Representative NE	Agricultural Experiment Station
Wangsness, P. J.	Animal Nutrition	Animal Science
Washko, J. B.	Forage Management	Agronomy
Wilson, L. L.	Animal Science	Animal Science
Yendol, W. G.	Non-Pesticide Insect Control	Entomology
<u>University of Rhode Island</u> Kingston 02881		
Henderson, B. W., Jr.	Animal Nutrition	Animal Science
Wakefield, R. C.	Management	Plant and Soil
<u>University of Vermont</u> Burlington 05401		
Bartlett, R. J.	Soil Science	Plant and Soil Science
Benoit, G. R.	Soil Physics	do.
Bornstein, J.	Agricultural Engineering	Agricultural Engineering
Gotlieb, A. R.	Plant Pathology	Botany
MacCollom, G. B.	Entomology	Entomology
McIntosh, J. L.	Soil Sciences	Plant and Soil Science
Magdoff, F. R.	Soil Sciences	Plant and Soil Science
Ranney, T. A.	Soil Sciences	Plant and Soil Science
Smith, A. M.	Animal Nutrition	Animal Sciences
Welch, J. G.	Nutritional Value	Animal Sciences
Wood, G. M.	Forage and Turf Mgmt.	Plant and Soil Science
<u>West Virginia University</u> Morgantown 26506		
Anderson, G. C.	Animal Nutrition	Animal and Veterinary Sci.
Baker, B. S.	Forage Management	Allegheny Highlands Project, Elkins, W.Va.
Balasko, J. A.	Forage Physiology	Plant Sciences
Bennett, O. L.	Forage Management	Plant Sciences and ARS, USDA
Butler, Linda	Entomology	Plant Sciences
Diener, R. G.	Agricultural Engineering	Resource Management
Elliott, E. S.	Root Diseases	Plant Sciences

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>West Virginia University</u> (cont'd.)		
Horvath, D. J.	Animal Nutrition	Animal and Veterinary Sciences
Kneefer, R. F.	Soil Fertility	Plant Sciences
Maxwell, R. H.	Agricultural Education	Allegheny Highlands Project, Elkins, W.Va.
Pohlman, G. G.	Soil Fertility	Plant Sciences (Emeritus)
Reid, R. L.	Animal Nutrition	Animal and Veterinary Sciences
Thomas, R. O.	Dairy Nutrition	do.
Toben, G. E.	Agricultural Economics	Resource Management
Ulrich, Valentin	Plant Breeding	Plant Sciences
Veatch, Collins	Weed Control	Plant Sciences (Emeritus)

<u>Name</u>	<u>Field of Research</u>	<u>Laboratory</u>
Beltsville Agricultural Research Center Northeastern Region, Agricultural Research Service U.S. Department of Agriculture Beltsville, MD 20705		
Bond, James	Beef Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Carlson, G. E.	Plant Physiology	Plant Physiology Institute Light and Plant Growth Lab
Chatterton, N. J.	Biochemistry	do.
Dinius, D. A.	Beef Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Goering, H. K.	Dairy Nutrition	do.
Hanson, C. H.	Forage and Range	National Program Staff, ARS, USDA
Klingman, D. L.	Weed Control	Plant Genetics and Germplasm Inst. Turfgrass Laboratory
Lindahl, I. L.	Sheep Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Lynch, G. P.	Dairy Nutrition	do.
Moe, P. W.	Energy Metabolism	do.
Murray, J. J.	Turfgrass	Plant Genetics and Germplasm Inst. Turfgrass Laboratory
Neal, J. W., Jr.	Forage Insects	Plant Genetics and Germplasm Inst. Applied Plant Genetics Laboratory
Oltjen, R. R.	Beef Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Ostazeski, S. A.	Plant Pathology	Plant Genetics and Germplasm Inst. Turfgrass Laboratory
Powell, J. B.	Genetics	do.
Ratcliffe, R. H.	Forage Insects	Plant Genetics and Germplasm Inst. Applied Plant Genetics Laboratory
Reynolds, P. J.	Sheep Nutrition	Nutrition Institute Ruminant Nutrition Laboratory

<u>Name</u>	<u>Field of Research</u>	<u>Laboratory</u>
<u>Beltsville Agricultural Research Center (cont'd.)</u>		
Rumsey, T. S.	Beef Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Schroder, R. F.	Forage Insects	Plant Genetics and Germplasm Inst. Applied Plant Genetics Laboratory
Tyrrell, H. F.	Energy Metabolism	Nutrition Institute Ruminant Nutrition Laboratory
Waldo, D. R.	Dairy Nutrition	do.

U.S. Regional Pasture Research Laboratory
 North Atlantic Area, Northeastern Region
 Agricultural Research Service
 U.S. Department of Agriculture
University Park, PA 16802

Barnes, R. F.	Forage Evaluation	U.S. Regional Pasture Research Lab.
Berg, C. C.	Genetics (Grasses)	do.
Byers, R. A.	Forage Insects	do.
Fissel, G. W.	Chemist	do.
Gross, C. F.	Soil Fertility	do.
Gustine, D. L.	Biochemistry	do.
Hill, R. R., Jr.	Genetics (Alfalfa)	do.
Hite, R. E.	Plant Pathology	do.
Jung, G. A.	Forage Management	do.
Kendall, W. A.	Plant Physiology	do.
Leath, K. T.	Pathology (Legumes)	do.
Sherwood, R. T.	Pathology (Grasses)	do.
Wilton, A. C.	Cytogenetics (Grasses)	do.
Zeiders, K. E.	Plant Pathology	do.

A Brief Description of the
U.S. Regional Pasture Research Laboratory
U.S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
North Atlantic Area, Northeastern Region
University Park, Pennsylvania 16802

HISTORY AND FACILITIES

The U.S. Regional Pasture Research Laboratory was established under Title I, Section IV of the Bankhead-Jones Act, approved June 29, 1935. Construction of the Laboratory began the summer of 1936 on land deeded by The Pennsylvania State University to the U.S. Department of Agriculture. By 1938 a two-story brick building for offices and laboratories, an adjacent headhouse, and three attached greenhouses were completed. In 1970, an addition to the original building was constructed to provide 80 percent more office and laboratory space. Also, another headhouse and one of three proposed greenhouses was built in 1973 on The Pennsylvania State University Campus about one half mile from the main Laboratory.

In addition to these facilities, the University has assigned approximately 50 acres of land at the Rock Spring Agricultural Research Center to the Laboratory. The Research Center, about 10 miles from the University, is three miles west of Pine Grove Mills on Route 45.

PURPOSE AND RESEARCH GOALS

The Laboratory's purpose is to investigate fundamental problems related to improving grasslands, forage crops, and cereals in the Northeastern United States. The Laboratory has developed a mission-oriented research program to improve the yield, the persistence, and the quality of plants. It does this by investigating biological, chemical, and environmental problems which are involved in producing and using grasslands, forage crops, and cereals. Basic and applied investigations are underway which involve biochemistry, chemistry, cytogenetics, entomology, forage management, genetics, plant breeding, plant pathology, plant physiology, and soil fertility.

ORGANIZATION

Four Research Units have been established at the Pasture Research Laboratory. An outline of the titles and primary responsibilities of each Research Unit and their research staff is shown on the following pages. The Laboratory is administratively located in the North Atlantic Area of the Northeastern Region. However, its research activities are conducted in cooperation with state and federal agencies at a number of locations throughout the region and nation. The Laboratory emphasizes the team-approach method for solving complex problems which are multidisciplinary in nature.

RESEARCH STAFF

RESEARCH UNIT 1 -- FORAGE CROPS QUALITY EVALUATION RESEARCH

Research Emphasis -- Alteration and Adaptation of Forage Legumes and Forage Grasses to Optimize Quality

ROBERT F. BARNES -- Laboratory Director, Research Leader, and Research Agronomist, ARS-USDA; and Adjunct Professor of Agronomy, The Pennsylvania State University.

Education: Iowa State University, B.S., 1957; Rutgers University, M.S., 1959; Purdue University, Ph.D., 1963.

Primary Research Activities: Development of laboratory methods of evaluating forage quality and their application to breeding, management, and physiological research problems. Influence of secondary plant metabolites on forage quality.

GUY W. FISSEL -- Chemist (Research Assistant), ARS-USDA; and Adjunct Instructor in Agronomy, The Pennsylvania State University.

Education: The Pennsylvania State University, B.S., 1952; M.S., 1955.

Primary Research Activities: Forage plant analysis of soluble and structural constituents.

DAVID L. GUSTINE -- Research Plant Physiologist, ARS-USDA; and Adjunct Assistant Professor of Agronomy, The Pennsylvania State University.

Education: Malone College, Canton, Ohio, B.A., 1964 (Chemistry); Michigan State University, Ph.D., 1969 (Biochemistry).

Primary Research Activities: Secondary metabolic constituents in plants influencing forage quality; biochemical basis of plant resistance to diseases and insects; regulation of protein synthesis during tissue differentiation.

WILLIAM A. KENDALL -- Plant Physiologist, ARS-USDA; and Adjunct Professor of Crop Physiology, Department of Agronomy, The Pennsylvania State University.

Education: University of Maine, B.S., 1949; Ohio State University, M.S., 1951; Ph.D., 1954.

Primary Research Activities: Plant growth and development. In vitro evaluation of forages. Physiology of parasitism of roots.

RESEARCH STAFF

RESEARCH UNIT 2 -- FORAGE CROPS DISEASE AND INSECT CONTROL RESEARCH

Research Emphasis -- Interactions of Diseases and Pests with Yield, Persistence, and Quality of Forage Legumes and Grasses

RICHARD R. HILL, JR. -- Research Leader and Research Agronomist, ARS-USDA; and Adjunct Associate Professor of Plant Breeding, The Pennsylvania State University.

Education: North Carolina State College, B.S., 1959; M.S., 1961; Cornell University, Ph.D., 1964.

Primary Research Activities: Quantitative genetics, statistics, and plant breeding; alfalfa improvement.

ROBERT A. BYERS -- Research Entomologist, ARS-USDA; and Adjunct Assistant Professor of Entomology, The Pennsylvania State University.

Education: The Pennsylvania State University, B.S., 1960; Ohio State University, M.S., 1961; Purdue University, Ph.D., 1971.

Primary Research Activities: Resistance of alfalfa to meadow spittlebug and alfalfa blotch leaf miner; effect of potato leafhopper and pea aphid on alfalfa quality; effect of insects on the yield and quality of grasses; effect of pea aphid in predisposing forage plants to plant diseases; artificial diet for alfalfa weevil.

KENNETH T. LEATH -- Research Plant Pathologist, ARS-USDA; and Adjunct Associate Professor of Plant Pathology, The Pennsylvania State University.

Education: University of Rhode Island, B.S., 1959; University of Minnesota, M.S., 1966; Ph.D., 1966.

Primary Research Activities: Pathology of forage crops, screening for disease resistance, inoculation methods, host-parasite interaction.

RESEARCH STAFF

RESEARCH UNIT 3 -- FORAGE PLANT-SOIL-CLIMATE INTERACTIONS RESEARCH

Research Emphasis -- Interactions of Soil, Plant, and Climate on Yield, Persistence, and Forage Quality of Legumes and Grasses

GERALD A. JUNG -- Research Leader and Research Agronomist, ARS-USDA; and Adjunct Professor of Agronomy, The Pennsylvania State University.

Education: University of Wisconsin, B.S., 1952; M.S., 1954; Ph.D., 1958.

Primary Research Activities: The physiology of cold and heat tolerance, plant responses to stress from clipping treatments in combination with varying degrees of environmental stress, factors that affect availability of energy and minerals in forages to livestock, and livestock-forage production systems.

CHARLES F. GROSS -- Soil Scientist, ARS-USDA; and Adjunct Instructor in Agronomy, The Pennsylvania State University.

Education: University of Vermont, B.S., 1953; University of Rhode Island, M.S., 1955.

Primary Research Activities: Factors affecting the mineral composition of forages.

RESEARCH STAFF

RESEARCH UNIT 4 -- FORAGE AND CEREAL CROPS BREEDING RESEARCH

Research Emphasis -- Alteration and Adaptation of Forage Legumes, Forage Grasses and Cereals to Optimize Yield and Cold Resistance

ROBERT T. SHERWOOD -- Research Leader and Research Plant Pathologist, ARS-USDA; and Adjunct Professor of Plant Pathology, The Pennsylvania State University.

Education: Cornell University, B.S., 1952; M.S., 1954; University of Wisconsin, Ph.D., 1958.

Primary Research Activities: Pathology of forage crops; effect of pathogens on plant biochemical constituents; nature of plant disease resistance.

CLYDE C. BERG -- Research Geneticist, ARS-USDA; and Adjunct Assistant Professor of Agronomy, The Pennsylvania State University.

Education: Kansas State University, B.S., 1958; Oklahoma State University, M.S., 1960; Washington State University, Ph.D., 1965.

Primary Research Activities: Developing and evaluating germplasm of cool-season perennial forage grasses; genetics and cytogenetics.

RAYMOND E. HITE -- Research Plant Pathologist, ARS-USDA; and Adjunct Assistant Professor of Plant Pathology, The Pennsylvania State University.

Education: Ohio State University, B.S., 1961; M.S., 1963; The Pennsylvania State University, Ph.D., 1972.

Primary Research Activities: Pathology of oats, ornamentals and forage crops; epidemiology; virology.

HAROLD G. MARSHALL -- Research Agronomist, ARS-USDA; and Adjunct Professor of Plant Breeding, Department of Agronomy, The Pennsylvania State University.

Education: Purdue University, B.S., 1952; Kansas State University, M.S., 1953; University of Minnesota, Ph.D., 1959.

Primary Research Activities: Breeding, genetics, and cytogenetics of oats. Winter hardiness, lodging resistance, interspecific hybridization, and breeding methodology. Buckwheat improvement.

RESEARCH UNIT 4 (cont'd.)

ARTHUR C. WILTON -- Research Agronomist, ARS-USDA; and Adjunct Associate Professor of Agronomy, The Pennsylvania State University. On leave to FAO/UN as Team Leader in Kenya, 1974.

Education: University of British Columbia, B.S.A., 1959; University of Saskatchewan, M.S., 1954; University of Manitoba, Ph.D., 1965.

Primary Research Activities: Cytogenetics of forages; grass breeding.

KENNETH E. ZEIDERS -- Plant Pathologist (Research Assistant), ARS-USDA; and Adjunct Instructor in Plant Pathology, The Pennsylvania State University.

Education: The Pennsylvania State University, B.S., 1955; M.S., 1958.

Primary Research Activities: Forage legume and grass diseases; screening for disease resistance; physiogenic diseases.

SECTION I

BREEDING, GENETICS, AND PLANT INTRODUCTION RESEARCH

Title: Promising Alfalfa Introductions of the 1973 Growing Season

Leaders: D. D. Dolan, F. L. Pflieger, and W. R. Sherring, New York (Geneva)

NOTE: F. L. Pflieger is now a Plant Pathologist with the Department of Plant Pathology, University of Minnesota

In 1972, the Regional Plant Introduction Station (Geneva) had two plantings of alfalfa introductions; one made in 1971, and the other made in 1972. Notes were taken on degree of infection with alfalfa leaf spot, Pseudopeziza medicaginis and a paper describing the relative susceptibility of the introductions was published in the Plant Disease Reporter. The alfalfa introductions in both plantings were rated for uniformity, habit, vigor, size of plant, crown width, size of stem, leafiness, time of bloom and degree of leafhopper damage. The following introductions of alfalfa appear promising in an overall view of these characteristics: P.I. 176638 Tur., 178982 Tur., 182238 Tur., 196218 Ind., 196225 Ind., 196233 Ind., 211608 Afgh., 222731 Iran, 230783 Ind., 255962 Can., 256337 W. Pak., 258065S Swe., 259524 Bulg., 263155 USSR, 268408 Afgh., 269387-88 Afgh., 287884 Sp., 287886 Afgh., 300578 USSR, 304527 Tur., and 341815 Can., G-12574 Md., G-12895 Ariz., G-14536 N.Y., G-20539 Pa., G-20540 Pa., G-20541 Pa., G-20547 Pa., G-20552 Pa., G-20555 Pa., G-22113 Rum., and G-22115 USSR.

In both the 1971 and 1972 alfalfa plantings, there was a severe infestation of leafhoppers especially during the first half of August 1972. On August 20, readings were made on the degree of damage due to leafhoppers and 20 introductions were relatively free. Seeds of these 20 introductions may be procured from the Coordinator.

Tolerance or resistance to alfalfa leaf spot seemed to be most prevalent in introductions of the species Medicago falcata. Explorers notes and collectors notes also indicate that some introductions of Medicago falcata are frost tolerant. The Regional Plant Introduction Station has seed of the following introductions of Medicago falcata: P.I. 325382 USSR, 325383 USSR, 325384 USSR, G-15178 USSR, G-15179 USSR, G-15184 Fr., G-20227 USA, and G-22112 Bulg.

The 1973 planting of alfalfa introductions consisted of 50 accessions. On June 14 and 15, 1973 notes were taken on uniformity, habit, vigor, size of plant, size and number of stems, leafiness, date of bloom, flower color, winter-hardiness, spring recovery, intensity of leaf spot and damage due to the alfalfa weevil. The following numbers appear worthy of further interest and further evaluation: P.I. 196218 Ind., 251530 Yugo., 268065S Swe., 289527 Ger., 293674 Grc., 300578 USSR, G-20227 Ind., and G-22112 Bulg.

Title: Report of Northeast Regional Plant Introduction Station, Geneva, N.Y.; and Regional Project NE-9 -- The Introduction, Testing, Multiplication and Preservation of Potentially Valuable Plants for Crop Improvement and Industrial Use

Leaders: D. D. Dolan, F. L. Pfleger, and W. R. Sherring, New York (Geneva)

The program at the Northeast Regional Plant Introduction Station, Geneva is carried out under Northeast Regional Project, NE-9. The objectives of this project are: growing, evaluation, control-pollination, seed increase, seed distribution and germplasm maintenance of introductions of forage legumes and forage grasses. Each year, the Northeast Plant Introduction Station receives approximately 600 such introductions that come from abroad and to us through the Germplasm Resources Laboratory, Genetics and Plant Breeding Institute, Beltsville, Md. Plants are started in peat pots in the greenhouse, moved to cold frames for several weeks and transplanted to the field in rod rows 3-1/2 to 4 feet apart. We have two replicates of each introduction and 18 plants in each replicate.

Evaluation notes are released in a biennial catalog of available introductions. The most recent covering 1972 and 1973 was published in January, 1974. Presented in tabular form and for each introduction are the following traits: country of origin, uniformity, habit, vigor, plant height, plant width, crown width, culm characteristics, leaf characteristics, flower color, pod shape, susceptibility to diseases and insects, recovery after cutting, percent winter survival and a rating for spring recovery. Seeds of these introductions are distributed to cooperators not only in the 12 northeastern states but in the whole United States. Each year performance and evaluation notes by our cooperators are assembled and published in Supplement I to the Annual Report of NE-9 entitled, "Promising forage legume and forage grass introductions of the year."

Title: Report of Northeast Regional Plant Introduction Station,
Geneva, N.Y.; and Regional Project NE-9 -- Promising
Alfalfa Introductions of 1973

Leaders: D. D. Dolan, F. L. Pflieger, and W. R. Sherring, New York
(Geneva)

Fifty introductions of alfalfa were carried over winter in the 1972 planting. Notes taken on June 14, 1973 indicated that the following introductions appeared promising: P.I. 267263 Tur., 251530 Yugo., 255962 Can., 259524 Bulg., 262550 Israel, 263155 USSR, 268065 Swe., 268065S Swe., 287884-86 Sp., 289527 Ger., 292773 Austral., 300578 USSR, 302927-29 Sp., and 341814-15 Can.

Alfalfa introductions showing the least weevil damage during 1973 are: P.I. 196224 India, 196245 India, and 263157 USSR.

Alfalfa introductions most free of leaf spot during 1973 are: P.I. 196225 India, 196233 India, 255962 Can., 262550 Israel, 292773 Austral., 300578 USSR, 302929 Sp., and 232927 Hung.

Alfalfa introductions entirely free of blackstem infection during 1973 are: P.I. 167263 Tur., 196225 India, 255962 Can., 287884 Sp., 287886 Sp., 300578 USSR, and 341814 Can.

During 1972, 20 introductions of alfalfa were found to be relatively free of leafhopper damage in a severe infestation. Seeds of these 20 may be procured from the Coordinator.

The 1973 alfalfa planting showed 5 introductions of Medicago falcata that were vigorous and leafy: P.I. 251689 USSR, 258752-54 Ussr, and 314092 USSR.

Four introductions of Medicago sativa in the 1973 planting were vigorous and leafy: P.I. 253444 Yugo., 234817 Switz., 251690 USSR, and 196226 India.

Cooperators who saw our 1973 planting, or reviewed our catalog of available introductions requested the following introductions of Medicago sativa: P.I. 86696 USSR, 205198 Tur., 302927 Sp., 174275 Tur., 178980 Tur., 256004 Fr., 277425 USA, 174275 Tur., 304265 USA, 341814 Can., 230225 Pa., 277425 USA, 277427 Den., 324893 Pol., 384508 USA, 384509 Ariz., 384510-12 Pa., 175789 Tur., 206110 Fr., 225543 Ger., 230225 Pa., 268066 Swe., 277427 Den., and 324893-96 Pol.

Title: Report of Northeast Regional Plant Introduction Station, Geneva, N.Y.; and Regional Project NE-9 -- Promising Forage Grass Introductions of 1973

Leaders: D. D. Dolan, F. L. Pfleger, and W. R. Sherring, New York (Geneva)

A promising domestic collection of smooth brome grass is G-20354 named "Goochland," because it was collected in vegetative condition by the Soil Conservation Service at Goochland, Virginia.

P.I. 341221 is also vigorous and leafy. It came from Canada and is an interspecies cross Bromus inermis x Bromus tytholepis.

An introduction of orchardgrass P.I. 325307 (USSR) is of value because of its vigor, leafiness and lateness of blooming.

An introduction of perennial ryegrass from the Netherlands (P.I. 303042) is more tolerant to rust and more tolerant to leaf spot than the commercial cultivar "Linn."

Two promising reed canarygrass introductions from the point of view of vigor and leafiness are P.I. 345662 USSR and 344557 Czech.

A timothy introduction (P.I. 371957 from Bulgaria) was promising for dark-green leaf color, certainly tolerance and possibly resistance to drought. In mid-September, it appeared especially attractive following a dry season. Another very acceptable timothy introduction was P.I. 376879 from New Zealand.

Other timothy introductions needing further evaluation for hay forage production are: P.I. 285539 Italy and 372626 Canada.

There is also one good pasture-type timothy: P.I. 372628 from Aberystwyth, Wales.

Title: Report of Northeast Regional Plant Introduction Station, Geneva, N.Y.; and Regional Project NE-9 -- Promising Red Clover and White Clover Introductions of 1973

Leaders: D. D. Dolan, F. L. Pflieger, and W. R. Sherring, New York (Geneva)

Red clover introductions most free of infection by *Stemphyllium* leafspot are: P.I. 303065-67 Fin., 303070 Fin., 303078 Fin., 306193 Gr. Brit., 315514 USSR, 315528-30 USSR, 325482 USSR, 345671 USSR and 345675 USSR.

Three red clover introductions in the field plots were relatively free of infection with powdery mildew: P.I. 303069 Fin., 345661 USSR and 345674 USSR.

The most vigorous and leafy white clover introductions in 1973 are: P.I. 256732 Tur., 314588 USSR, 345529 Austral., 350706 Austral., 367898 Ger., and 376882 N. Zeal.

Six white clover introductions most free of virus infection are: P.I. 223822 Afgh., 224680 Eng., 234679 Fr., 319138 Sp., 345530 Austral. and 350706 Austral.

Title: Regional Project NE-74 -- Breeding of Improved Varieties of Forage Species Adapted to the Northeast

Leader: W. D. Pardee, Cornell University, Chairman, Regional Technical Committee

Experiment stations and other agencies with contributing projects:

The Connecticut (Storrs), Maryland, New Hampshire, New York (Cornell), and Pennsylvania Agricultural Experiment Stations; and the U.S. Regional Pasture Research Laboratory, USDA-ARS, University Park, Pa.

Experiment stations and other agencies represented on the technical committee without a contributing project:

The Delaware, Maine, New Jersey, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations; Cooperative State Research Service, USDA; Applied Plant Genetics Laboratory and Turfgrass Laboratory, ARS-USDA, Beltsville, Md.; and the American Seed Trade Association

Strain synthesis procedures, seed production and strain evaluation for forage species important to the Northeast were continued in 1973. Work is in progress on seven species at five Northeastern State Experiment Stations; and ARS-USDA at the U.S. Regional Pasture Research Laboratory and at Beltsville, Md.

I. Studies on strain synthesis:

Alfalfa. Syn 3 seeds of 100 experimental synthetics with 1 to 16 parental clones were produced (Past. Lab.). Inbred lines from the Saranac and Iroquois varieties are also being produced to use in synthesis combinations to study parent line inbreeding effects on variety performance (N.Y.).

Orchardgrass. Average performance of different types of synthesis products derived from parent clones of Pennmead and Pennlate orchardgrass did not differ significantly from each other or from their source variety. No advantage was shown for these alternative techniques over the standard synthesis method.

Timothy. Comparisons of synthesis progenies show a shift towards earlier anthesis with each additional seed increase generation, a factor to be considered during seed increase of late maturing timothy varieties. One generation of inbreeding had little effect on forage performance but did reduce seed production.

II. Genetic studies:

Alfalfa. In Pasture Laboratory studies parental genotype had significant effects on the degree of inbreeding depression of vigor. While average vigor decreased with inbreeding, exceptions existed. The degree of parental inbreeding did not have a consistent effect on general or specific combining ability.

Crownvetch. In matings of 50 randomly selected plants from the variety Chemung, heritability estimates were found to be low for forage yield and plant height. Estimates for total genetic variance were significant for all characters except first cutting yield (Pa.).

Smooth bromegrass. Significant differences were noted between fourteen experimental lines but not between seven brome grass cultivars for stomatal aperture. Less total aperture was noted on 4N (tetraploid) than on 6N or 8N lines (N.H.).

III. Seed production:

Foundation seed fields were established in Idaho for Saranac AR, a Saranac type variety resistant to southern anthracnose; Honeoye, a Saranac type variety with higher yield potential (formerly Syn L) and an unnamed multifoliolate synthetic. Three other synthetics were increased in cages in Idaho. Beltsville 71, an anthracnose resistant variety developed from Team, will be increased in 1974.

Timothy. Foundation seed fields were established in Minnesota and Oregon for Champlain timothy (formerly TM 64-23). Seed increases of medium to late maturity synthetics were produced for regional forage evaluation.

Lolium-Festuca hybrids. Artificial air movement did not significantly increase seed production of Lolium-Festuca hybrids in muslin cages (Past. Lab.). Such cages did facilitate mutual pollination of a group of plants, but seed yields were low.

IV. Evaluation of new synthetics:

Promising public and privately developed alfalfa varieties are being evaluated in uniform trials in NY, Pa. Conn., and Md. to compare performance over the Northeastern Region. In recent tests, 4 anthracnose resistant strains selected from susceptible varieties by ARS all ranked high in yield where anthracnose was present, and equal to their susceptible source when anthracnose was absent.

Title: Regional Project NE-75 -- Breeding for Improved Forage Quality

Leader: A. W. Hovin, Minnesota, Chairman, Regional Research Committee

Experiment stations and other agencies with contributing projects:

Minnesota, New York (Cornell), Pennsylvania, South Dakota, and Wisconsin Agricultural Experiment Stations; and the U.S. Regional Pasture Research Laboratory, ARS-USDA, University Park, Pa.

Experiment Stations and other agencies represented on the technical committee without a contributing project: The Connecticut (Storrs), Maryland, New Hampshire, New Jersey, and West Virginia Agricultural Experiment Stations; Cooperative State Research Service, USDA; and Applied Plant Genetics Laboratory, Light and Plant Growth Laboratory, and Turfgrass Laboratory, ARS-USDA, Beltsville, Md.

I. Characterize the variability in plant constituents:

General combining ability (GCA) was significant for acid-pepsin dry matter disappearance (APDMD) of total smooth brome grass herbage cut at two harvest dates and of the leaf blades at the first harvest (Wis.). GCA was highly significant for in vitro dry matter digestibility (IVDMD) in reed canary-grass, but specific combining ability (SCA), year x crosses and location x crosses interactions were nonsignificant (Minn.). No relationship was established between smooth brome grass genotypes grown as spaced plants and in solid-stand plantings (SD). Smooth brome grass genotypes with improved regrowth showed significant differences in IVDMD, net carbon dioxide exchange, and several agronomic traits (SD). Significant differences for IVDMD, acid detergent fiber, lignin, and cellulose were obtained for Lolium-Festuca hybrid derivatives (Past. Lab.). Significant differences for IVDMD and dye binding analysis of crude protein were obtained for alfalfa (NY). Preliminary analyses of data from diallel crosses in alfalfa indicated relatively high heritability estimates for acid-detergent

fiber, lignin, and concentration of K, Ca, Mg, Mn, and B. These estimates were higher than those for IVDMD, P, Fe, Cu, Al, Zn, and Na (Past. Lab.). Multiple regression analysis showed that the three most important factors in determining IVDMD of big bluestem were IVDMD of stems, leaves, and percent leaves (SD). Foliar fungal disease significantly reduced IVDMD but two strains of brome streak virus showed no change in IVDMD of smooth brome grass (SD). Shading increased concentration of total indole alkaloids which is negatively correlated with palatability in reed canarygrass (Minn.) Fertilizer containing N as NH_4 resulted in higher alkaloid concentration than when N was in the form of urea or NO_3 (Minn.) Alkaloid concentration of leaf blades was over twice that of sheaths and stems in reed canarygrass. Refinement in sampling resulted from the use of leaf blades only or the top 1/3 of the plant (Minn.) Frequency distribution of the 3 major alkaloids and their mixtures was used to describe reed canarygrass varieties (Minn.)

II. The application of approximate techniques:

Significant correlation between acid-pepsin and in vitro dry matter disappearance was obtained for June harvest of Lolium-Festuca derivatives with no major differences in ranking of genotypes. The results suggested that initial screening for improved digestibility could be made by the APDMD method (Past. Lab.) Orchardgrass clones preferentially grazed by sheep were established in replicated field trials for further observations (Pa.) The meadow vole was used to monitor the chemical fractionations of an antiquality constituent in crownvetch forage (Pa.) The substance was identified as β -nitropropionic acid (Past. Lab.) A mathematical model was developed whereby the potential economic returns (dollars/acre) in milk production were predicted from the TDN, protein (P) and yield of a forage variety. In general, an increase of 1% TDN, and 0.6% P is equal to 0.13 tons/acre, or about \$25/acre more than the standard variety (Pa.)

III. The development of source populations:

New cycles of selection were made for improved quality components in alfalfa (Past. Lab.); crownvetch, orchardgrass (Pa.); reed canarygrass (Minn.); and smooth brome grass (SD, Wis.)

IV. Plant morphological and physiological characteristics:

Consistent differences in morphological traits were observed for Lolium-Festuca derivatives that were absent in their polycross progenies (Past. Lab.) Wide leaves, coarse culms, and dark plant color were positively associated with APDMD in smooth brome grass (Wis.) IVDMD and protein concentration of orchardgrass synthetics varied with season irrespective of maturity differences (Pa.) Alfalfa clones and progenies differing in leaflet numbers and leaf-stem ratio were compared for forage quality (NY). Leaf/stem ratio affected IVDMD more than leaflet number. IVDMD was inversely related to plant height. Protein determined by a dye-binding method was positively related to IVDMD (NY).

V. The production of synthetic varieties:

Synthetics are being developed in several species for agronomic and animal performance evaluations.

Title: Breeding Alfalfa for Disease and Insect Resistance

Leaders: T. E. Devine and R. H. Ratcliffe, Beltsville, Md.

A new alfalfa variety 'Arc' was released by the Agricultural Research Service in cooperation with the Agricultural Experiment Stations of Maryland, North Carolina, Pennsylvania and Virginia, in 1974. Arc is distinguished by its high resistance to anthracnose. It is also highly resistant to the pea aphid and moderately resistant to bacterial wilt and the alfalfa weevil.

Stand counts and estimates of percent cover taken at seven locations in Maryland, North Carolina, Pennsylvania, and Virginia where anthracnose and/or bacterial wilt were problems showed Arc to be more persistent than most check varieties. Under severe anthracnose epiphytotic striking differences in persistence between Arc and check varieties developed as early as the first season of growth.

Arc demonstrated a moderate level of tolerance to larval feeding by the alfalfa weevil when exposed to conditions of high infestation in the field. In five location test years out of nine in three states, Arc was equal to Team in tolerance to larval feeding damage and in four locations was significantly more tolerant than Team. Alfalfa yields for Arc were superior to most check varieties in tests at Beltsville, Clarksville, and Wye Mill, Md.; Clayton, Salisbury, and Raleigh, N.C.; Manhattan, Kansas; and Blacksburg, Va. Yield superiority generally increased with age of stand. Hay yields at Landisville and Rock Springs, Pa.; Ithaca, N.Y.; Mead, Nebr.; Warsaw, Va.; and Wooster, Ohio were equal to or better than check varieties.

Title: Breeding Alfalfa for Tolerance to Aluminum Toxicity in Acid Soils

Leaders: J. E. McMurtrey III, T. E. Devine, A. L. Fleming, and C. D. Foy, Beltsville, Md.

Aluminum toxicity is believed to be a factor restricting root growth in the lower horizons of many soils in the eastern U.S. Such restricted root growth limits the potential uptake of moisture. This may result in

reduced forage production during the summer months when there are frequent periods of moisture stress.

A recurrent phenotypic selection program for tolerance to aluminum toxicity in acid soils is being carried on in a broad based population with multiple pest resistance. The program is designed to combine tolerance to aluminum toxicity in acid soils with high resistance to anthracnose and pea aphid, and moderate resistance to the alfalfa weevil and bacterial wilt. Two cycles of selection have been completed.

Two other populations are being selected by recurrent selection for contrasting reactions to aluminum toxicity. One is being selected for tolerance and the other for susceptibility. These populations have undergone 3 generations of selection and intercrossing. They are broad based populations originating from six cultivars (DuPuits, Atlantic, Team, Buffalo, Grimm and Sirsa-9). Baden and Tatum soils high in aluminum ions, have been used as the stress medium. Seedlings tested from the second cycle indicate that selection has been effective in differentiating these populations.

Title: Inbreeding in Alfalfa

Leader: R. R. Hill, Jr., Pasture Research Laboratory

Spring growth and plant height at each of three harvest times in each of two years were studied in progenies from three clones each in MSA-W4 and MSB-W4 alfalfa. In increasing order of level of inbreeding, the generations of five clones were S_0 , S_1 , S_1 SYN-1, S_2 -SYN-1, S_3 -SYN-1, and S_3 . One of the clones in MSB-W4 had the S_4 -SYN-1 generation, but not the S_1 -SYN-1. Data were analyzed by multiple regression on the coefficient of inbreeding and by a newly developed genetic model for two-allele, autotetraploid populations.

Generally, mean squares for deviations from multiple regression on the coefficient of inbreeding were smaller than those for deviations from the genetic model. Significant deviations within families often accompanied significant average regression or average effects in the genetic model, indicating that the genotype of the parent had a significant effect on the response to inbreeding. One clone showed almost no decline in vigor with increasing inbreeding, but others showed significant declines. In several progenies, the S_3 -SYN-1 generation was less inbred and less vigorous than the S_3 generation. Unavoidable selection during development of the progenies seemed important in the observed responses.

Diallel crosses were attempted between S_0 , S_2 , and S_4 parents from MSA-W4 and MSB-W4 alfalfa. Incomplete diallels were obtained with most of the S_2 and S_4 parents. First harvest dry matter yields were measured in small row plots during each of two growing seasons.

Average yields of the S_2 -crosses were less than those of the S_0 -crosses in all cases. Individual exceptions to this average trend occurred in both populations, but were more frequent in MSA-W4 than in MSB-W4. The number of S_4 -crosses was small and the results with them were variable. Yields of all S_4 -crosses from MSA-W4, which had one parent common to all crosses, were greater than yields of the corresponding S_0 - or S_2 -crosses. S_4 -crosses from MSB-W4 were among the lowest yielding of all crosses.

Mean squares for both general and specific combining ability in MSA-W4 increased from the S_0 to the S_2 parental generation. This increase was greater for specific combining ability than for general combining ability. General combining ability was significant in the S_0 -crosses from MSB-W4, but no combining ability mean square was significant in the S_2 - or S_4 -crosses from this population.

Title: Inheritance of Quality Components in Alfalfa

Leaders: R. R. Hill, Jr., G. A. Jung, and R. F. Barnes, Pasture Research Laboratory

Diallel crosses made with parents randomly selected from Saranac alfalfa were studied for concentrations of P, K, Ca, Mg, Mn, Fe, B, Cu, Al, Zn, Na, in vitro digestibility (IVDMD), lignin, and acid detergent fiber (ADF). IVDMD, lignin, and ADF were also measured in diallel crosses from MSA-C4 alfalfa. Significant additive genetic variance was observed for each of the mineral elements except Cu-, Al-, Zn-, and Na-concentrations. At the soil fertility levels of our experiment, alfalfa contained less P, Cu, Zn, and Na, more K and Ca, and a higher Ca/P ratio than recommended for a moderately producing dairy cow. Deviations from the recommended levels of the remaining elements were minor and considered unimportant. Estimated potential ranges of mineral concentrations that could be achieved through plant breeding indicated that (1) the P-deficiency could be corrected; (2) correction of the Zn-deficiency and the excessive Ca/P ratio would be possible, but difficult; and (3) correction of deviations from dairy cow requirements for Cu, Na, K, and Ca could not be accomplished through plant breeding without alteration of soil fertility levels.

Analyses of the IVDMD, lignin, and ADF data have not been completed. However, preliminary inspection of the data indicate that lignin has higher heritability than either IVDMD or ADF.

Title: Breeding and Cytogenetics of Alfalfa and Red Clover

Leaders: R. W. Cleveland, M. L. Risius, and J. S. Shenk, Pennsylvania

Field trials of alfalfa varieties were conducted in two counties of Pennsylvania. Anthracnose disease appears to have had a major effect on the performance of alfalfa varieties grown in Lancaster, but not in Centre County (the disease has been reported as serious in several parts of southeastern Pennsylvania). In a Lancaster trial, yield and percentage stand in 1973 appeared to be negatively correlated with anthracnose intensity in 1972. The varieties best able to withstand anthracnose were four experimental strains from USDA (Beltsville) research. The most diseased varieties commonly used by farmers in Pennsylvania were Saranac and Iroquois. Both are excellent performers in the absence of anthracnose. Vernal had a moderate level of resistance, and seed is available commercially.

We have established nurseries that contain our alfalfa breeding material in an area where anthracnose is prevalent. Evaluations for disease resistance will be conducted in coming years.

Selections were made of creeping rooted alfalfas that are to be used as parents in a recurrent selection program. Evaluations for disease resistance are planned with emphasis on bacterial wilt and anthracnose.

Red clover breeding for resistance to northern anthracnose and other diseases was conducted. Nurseries for the evaluation and selection of parental material were established.

Title: Breeding and Genetics of Birdsfoot Trefoil for the Northeast

Leader: H. M. Schaaf, USDA-ARS, New York (Cornell)

A picrate assay was developed which is in accord with precise biochemical data and which differentiates three cyanic phenotypes in birdsfoot trefoil: G+E+, G+E- and G-E+ or G-E-. Use of the assay to analyze hybrid progenies confirmed the hypothesis that cyanogenesis in trefoil is conditioned by two independent loci. Segregation at each locus was tetrasomic. There is evidence that the content of cyanoglucoside and the level of Beta-glucosidase activity in the disrupted tissue of any trefoil plant both depend, in part at least, upon the number of functional alleles at the two respective loci. Reproductive disturbances are suspected on the basis of differences between certain reciprocal crosses. The genotype of three G+E+ plants has been established as GgggEEEE, that of one G+E- plant as Ggggeeee, and that of one G-E+ plant as ggggEEeE or ggggEEee.

New increases of VN-2 (an ostensible acyanogenic birdsfoot trefoil) were limited to plants of the G+E- phenotype for the purpose of purging the strain of the allele conditioning Beta-glucosidase activity, and thereby of G+E+ phenotypes in future generations. The purged plants that gave glucoside-free assays are being progeny-tested to verify their lack of the allele controlling cyanoglucoside content.

The project is being revised. There will be greater emphasis on breeding for seed production and on the interaction of cultural factors that determine harvestable seed yield. The former will include an investigation of cross-compatibility. The latter will involve field study of the individual and combined effects of insect control, weed control, soil fertility, and stand density.

Title: Breeding Crownvetch for Forage and Slope Stabilization Usage

Leaders: M. L. Risius, J. S. Shenk, and R. W. Cleveland, Pennsylvania

Quality changes in first growth forage from three crownvetch cultivars were evaluated during the spring in each of two growing seasons. No significant differences among cultivars (Penngift, Chemung, and Emerald) were found. Significant changes in percentage dry matter, protein, in vitro dry matter disappearance, and cell wall constituents occurred from late May to late June. Year effects for most quality factors were significant.

Variation among plants for quality traits was characterized. Individual plants of Penngift and Chemung cultivars were significantly different for morphological traits, IVDMD and protein concentration over years. Although dry matter, protein, and estimated digestibility from cell wall constituents were significantly correlated with IVDMD, none of these relationships were strong enough to use for predictive purposes.

Title: Red Clover Forage Yield and Stand Persistence Study

Leaders: A. M. Decker and C. S. Garrison, Maryland and USDA-ARS, Beltsville, Md.

Thirty-one Kenland and 10 Chesapeake entries plus Kenstar were harvested three times in 1973 (second harvest year). Stands were rated in the spring and again in the fall for ground cover and general plant vigor.

There were wide differences in both stand ratings and forage yields. From preliminary results, it appears that the area of seed production can

markedly influence both forage yields and stand persistence. In general, seed produced in the Northwest was equal to breeders seed while that grown in California was inferior in terms of forage yield and stand persistence.

Stands were rated in late spring of 1974, and entries with adequate stands will be harvested during the 1974 growing season.

Title: Breeding and Cytogenetic Investigations and Improvement of Cool Season Perennial Forage Species

Leaders: R. P. Murphy and C. C. Lowe, New York (Cornell)

The following new forage crop varieties were released by the Cornell University Experiment Station in 1973: Saranac AR alfalfa, Honeoye alfalfa, and Champlain timothy. Certified seed of Saranac AR should be available in 1975; seed of Honeoye and Champlain should be available in 1976.

Twenty-seven alfalfa clones were field selected for tolerance to alfalfa blotch leaf miner. These are being intercrossed for further selection. A nursery is to be established in 1974 to select for possible tolerance to the alfalfa snout beetle. Populations of this highly-destructive, parthenogenic, wingless weevil have been increasing with the decline in use of persistent insecticides.

Current work with the multifoliolate character in alfalfa centers on seed production. Previous efforts on commercial scale seed production for a variety carrying this character suggest seed production difficulties. Seventy-six clones were selected in an Idaho production field; they have been interpollinated and progenies established under irrigated conditions in Idaho for further seed production selections. The multifoliolate character is being studied by IVD and dye binding laboratory techniques to determine the character's influence on forage digestibility and protein content. Synthetic combinations possessing the character are being studied and a diallel cross series of multifoliolate and trifoliolate clones with high and low leaf/stem ratios is being worked with to determine how these contribute to forage quality.

Forage quality studies with timothy have so far not indicated any meaningful digestibility differences nonrelated to plant maturity. Synthetic combinations based on maturity consistently check out as predicted for determinations made on digestibility. Season yield potential, however, also checks out as predicted. Some selection work has been started with earlier materials. Over 5.5 tons of dry matter were harvested in two cuttings in a wet season in northern New York in 1973 on both late and early timothy varieties. Eighty percent of the total was harvested at pre-anthesis stage in late June; quality of the above was good to

excellent. Under the same conditions, corn planting was delayed until July and perennial legume stands were severely damaged or destroyed. While this represents an extreme climatic situation, the problems exist to a degree in all seasons. They emphasize the continuing importance of this perennial grass species to balanced roughage production in the many areas of the Northeast with soil drainage difficulties.

Title: Breeding of Improved Varieties of Forage Species Adapted to the Northeast

Leaders: J. S. Shenk, M. L. Risius, and R. W. Cleveland, Pennsylvania

Field evaluation of the synthesis products among the four parental clones of Pennlate (PL) and Pennmead (PM) orchardgrass was conducted at Pennsylvania, New York, and Maryland in cooperation with AES personnel. The objective was to determine if significant improvement in yield could be obtained by different methods of synthesizing the varieties from the four parental clones. The synthesis products tested were conventional synthetics (CS), restricted polycrosses (RP), two types of single crosses (SC), and three types of double crosses. The first study harvested at Pennsylvania and New York consisted of only a portion of the possible synthesis combinations and was completed after 3 years. At both locations all products tested were not significantly higher in yield than CS. No trend among combinations of synthesis products of PL or PM clones was found over locations.

The second experiment consisting of a complete set of PM combinations was analyzed for the first year at Pennsylvania and New York. No consistent pattern of differences existed among synthesis products within or over locations, and no combination significantly outyielded the conventional PM synthetic. A third experiment containing a complete set of PL combinations was harvested for the first year at Pennsylvania and Maryland. One entry, RP of clone XLI-8 significantly outyielded the conventional PL synthetic. Progeny of clone XLI-8 were also highest in yield in both types of single crosses. This was not the case at Maryland where no significant differences or trends existed among synthesis products and conventional synthetics.

Title: Breeding of Perennial Forage Grasses

Leaders: J. S. Shenk, M. L. Risius, and R. W. Cleveland, Pennsylvania

A 2-year study was completed to examine the potential of improving the quality of orchardgrass forage by breeding. Significant variation was

found to exist among clones for in vitro dry matter disappearance (IVDMD) and protein. Clones must be evaluated over more than 1 year and harvest. Plant height was positively correlated with the production of cell walls (fiber) but both plant height and cell wall constituents were negatively correlated with IVDMD and protein. Plant morphological characteristics were of little assistance in identifying clones of high forage quality.

A phenotypic recurrent selection program was continued with 4 populations (A,B,C,D) to improve the production of quality orchardgrass forage. Selection of clones was based on above average performance in vigor, height, and in vitro dry matter disappearance (IVDMD). After 2 years of evaluation, 75 clones were chosen from population B and combined into two crossing blocks according to maturity. Population C was screened for the first time for superior clones. A number of outstanding clones was found in Russian introductions. A new population of over 2,000 clones was established from introduction sources to form population D. Clones in nursery A were grazed by sheep during early-spring growth and mid-summer aftermath. Clones preferred by sheep over harvests were planted in a replicated field trial to study this method of evaluating clones for the quality improvement program.

The influence of plant morphology and maturity on forage yield and quality was investigated in a field plot trial containing 10 experimental synthetics, Pennlate and Pennmead. One of the highest yielding synthetic was derived from parental clones selected to be tall and upright in growth habit from population A. Early, medium and late maturing synthetics did not differ significantly in dry matter yield/hectare. Very late maturing synthetics yielded significantly less than the other synthetics.

Title: Breeding and Genetics of Bromus inermis

Leaders: G. M. Dunn, H. Z. Lea, and G. Y. Tan, New Hampshire

Blair, Fox and Saratoga brome grass cultivars continued to perform relatively well in comparison to other cultivars and synthetics in two yield trials.

Significant differences were obtained in total stomatal aperture (estimated indirectly with a diffusion porometer in the field) among 14 experimental lines of brome grass. Preliminary data indicated significantly less total aperture on 4N than on 6N or 8N ploidy level, measured on clear days in the greenhouse. Stomatal length was positively related and frequency inversely related to ploidy level. Stomatal length is a good index for screening for polyhaploid (4N) plants in this species, and reliable measurements can be obtained on the cotyledonary leaf of seedlings. Stomatal length increased and frequency decreased progressively from top leaf to fourth leaf from panicle.

Title: Genetic Variation in Forage Quality of Smooth Brome grass

Leaders: D. W. Koch and G. M. Dunn, New Hampshire

Twenty-one varieties and experimental synthetics of smooth brome grass have been evaluated for variation in forage quality traits. In vitro dry matter digestibility (IVDMD) varied from 52 to 64% in 1972 and from 53 to 66% in 1973. There was significant year to year variation in IVDMD. Cell wall constituents varied little among genotypes. Acid-detergent fiber, acid-detergent lignin, and silica contents are being determined in order to establish the relationship between cell wall components and IVDMD.

Title: Lolium x Festuca Hybrid Derivative Studies

Leaders: C. C. Berg and R. T. Sherwood, Pasture Research Laboratory, University Park, Pa.

The perloline content of 15 Lolium x Festuca hybrid derivative clones harvested from field plots at three times during each of 3 years was measured. Certain clones were consistently high in the alkaloid and others were consistently low; however, some clones showed a genotype x harvest date interaction within years. Perloline content was not associated with net blotch severity, yield, IVDMD, or lignin content.

The relation of sclerenchymatous tissue in the leaf to the severity of net blotch was also tested for these 15 clones. In both field-grown and greenhouse-grown leaf samples, the clones showed significant differences in the average distance between sclerenchyma girders (or ribs), the percent cross-sectional area of the leaf occupied by girders, and the percentage of incompletely formed girders. The net blotch severity rating was not directly correlated with any of these aspects of leaf architecture; although well developed girders often limited the lateral extent of the lesions.

Title: Mutagenic Effects of Gamma-Rays on Vegetatively Propagated Kentucky Bluegrass

Leaders: J. B. Powell and J. J. Murray, Beltsville, Md.

Several experiments were conducted in 1973 to establish the radio sensitivity of rhizome and crown material of Kentucky bluegrass. The rhizome of Belturf Kentucky bluegrass was irradiated and propagated by single shoots

for transplanting to the field. Mutations were induced in this material. We are currently selecting changes in growth habit and earliness. The irradiated material will be evaluated for disease resistance and summer heat tolerance.

Title: Yield and Quality of Perennial Ryegrass Cultivars

Leaders: C. C. Berg and G. A. Jung, Pasture Research Laboratory,
University Park, Pa.

Twenty-six cultivars of perennial ryegrass were evaluated for agronomic characteristics in field plots. All but one cultivar survived the first winter (moderate temperatures) and all surviving cultivars survived both wet and dry conditions. Some cultivars flowered in early June, others in mid-June, while others failed to produce inflorescences. Cultivars that remained vegetative produced lower first harvest yields, but higher second and third harvest yields than cultivars that flowered. Forage yields from Pennmead orchardgrass were equal to or exceeded yields from ryegrass cultivars at each harvest. There were only minor differences in in vitro dry matter disappearance (IVDMD) at the August 25 harvest, except that Pennmead orchardgrass was about 4.5 units below the lowest perennial ryegrass. At the September 26 harvest there were wider quality differences among the ryegrass cultivars, but none were significantly lower than Pennmead.

Title: Northeast Seed Use Survey of Small Seeded Legumes and Grains

Leader: William D. Pardee, New York (Cornell)

This survey of wholesale seed shipments is conducted annually to measure shifts in seed use of small seeded forage legumes and grasses. Long-term trends are useful in planning research and extension activities and help seedsmen in developing production plans.

Results in 1973 show total alfalfa seed sales for the 12 Northeastern States at just over 6 million pounds, up 9% from 1972 and nearly double the volume sold in 1969. Saranac and Iroquois were the most popular varieties, totaling 53% of the volume. Private varieties made up 28% of sales.

Seed sales of most other grasses and legumes were up from the previous year, although the long-term trend has been down. Birdsfoot trefoil was the only species showing a decline, due to short seed supplies. Results of this survey reflect the strong use by Northeastern farmers of varieties developed in research programs in the region.

SECTION II

ENTOMOLOGY RESEARCH

Title: Development of a Sequential Sampling Scheme to Predict Damaging

Leaders: A. L. Steinhauer and L. M. Stevens, Maryland

Research on alfalfa weevil in 1973 centered on the development and testing of a sampling scheme that would be suitable for predicting the necessity of spraying for the control of the alfalfa weevil. Present recommendations call for a visual damage threshold (50-75%) for timing of spray applications. In much of Maryland, this visual threshold may be reached, but the necessity to spray would have passed, since the abundance of alfalfa weevil larvae may be too low to cause economic damage. Reliance on the visual threshold may thus result in unnecessary spraying of alfalfa. In order to establish the need for spraying, we have developed a sequential sampling method in which a number of stems are picked from a field and subsequently examined for the presence of 1st and 2nd instars. The numbers found per stem are plotted on a chart and the need to spray or not when the visual threshold is reached is read off the chart. This method allows growers to determine as much as a month in advance whether application of pesticide will be necessary. The method is being studied on a pilot basis during the 1974 growing season, and may be modified before finalization. Interested workers may obtain a copy of the complete method and chart by writing A. L. Steinhauer, Department of Entomology, University of Maryland, College Park, Maryland 20742.

Title: Effect of the Alfalfa Weevil on Alfalfa Yield, Quality, and Morphology

Leaders: Gary W. Fick, Beverly Wen-Yuh Liu, and George A. Maybee, New York (Cornell)

Alfalfa weevil populations (peak of 2.7 larvae/stem) that significantly reduced seasonal DM yields by 1.72 MT/ha also significantly reduced the yield of digestible DM (1.37 MT), CP (0.30 MT), and leaves (0.75 MT). Uncontrolled populations (peak of 1.1 larvae/stem) that reduced seasonal yields by only 0.44 MT/ha (not significant) had no influence on digestible

DM, CP, or leaf yields for the season, although leaf yields were reduced significantly in the July harvest following the period of peak weevil feeding. The higher level of weevil feeding altered the pattern of TNC accumulation in the taproots, but the lower larval population had no influence on this factor. These weevil populations are typical of the range of infestations found in New York State in recent years.

Although differences in the total leaf yields were found, we could detect no effect of the natural weevil populations on leaf percentage. This could be due to the inclusion of plant parts other than blades in the leaf fraction, but it may also indicate growth mechanisms that maintain the leaf percentage at the weevil populations studied. Therefore we initiated detailed separations of alfalfa herbage to determine (a) how the fractionation of the plant influences the apparent leaf percentage, and (b) how weevil feeding alters the weight and percentage by weight of the various parts. Our standard separation procedure placed plant parts other than blades (petioles, stipules, flowers, seed pods, and stem tips) in the leaf fraction. In undamaged samples from late bud through the 35% seed pod stages, these parts represented a nearly constant 10% of the herbage DM. In weevil damaged samples, only blade removal could be detected. Therefore, inclusion of parts other than blades in the leaf fraction decreased the effect of weevil feeding on apparent leaf percentage.

Title: Effect of the Blotch Leafminer on the Quality of Alfalfa Hay

Leader: George MacCollom, Vermont

Evaluation of four insecticides against the alfalfa blotch leafminer, Agromyza frontella, was initiated. One year's data indicated that as much as 38% of the leaflet could be mined with no reduction in yield or quality as measured by percentage of protein, digestibility, or lignin; when no field-loss of leaflets occurred. The loss of mined leaves in field cured hay may result in reductions in quality, however. This aspect is being studied during 1974.

Title: Studies on the Impact of Certain Organic Synthetic Insecticides on the Alfalfa Weevil Parasite, Microctonus aethiops (Nees) (Braconidae: Hymenoptera)

Leaders: R. Dumbre and A. A. Hower, Pennsylvania

The role of natural enemies in suppressing alfalfa weevil populations is being increasingly recognized. However, the use of insecticides is inevitable. Therefore, a study was undertaken to determine the effect of Furadan^R, methyl parathion, Supracide^R and methoxychlor on Microctonus aethiops, an adult parasite of alfalfa weevil.

Insecticides procured as technical grades, were dissolved in acetone. Median lethal doses were determined for nonparasitized and parasitized weevils at different times from initial parasitization until emergence of parasite larvae. Furadan was the most toxic compound followed by methyl parathion, Supracide and methoxychlor. Parasitized weevils were more susceptible than nonparasitized ones when larval development of the parasite started inside the host.

Some aspects of the biology such as longevity, reproductive potential and sex ratio of the parasites emerging from insecticide treated hosts were studied. There was no significant difference between the parasites emerging from hosts treated with an LD50 or an LD90 dose and those emerging from untreated hosts. Dissection of moribund and dead parasitized weevils invariably indicated that the hosts mortality preceded that of its endoparasites. Parasites either did not emerge or emerged structurally and functionally normal.

Median lethal doses were also determined for parasite adults and pupae. The pupal stage was 80 to 90 times more resistant than the adult stage. The sublethal doses, had however, detrimental effects on survivors as seen from reduced longevity and reproductive potential. Sex ratio remained unaffected.

Title: Control and Bionomical Studies of Livestock and Animal Food Crop Insects in West Virginia

Leaders: Linda Butler, Joseph E. Weaver, West Virginia

Bio-control studies of the alfalfa weevil were emphasized. Surveys for incidence, distribution and establishment of released parasites were continued. Bathyplectes curculionis and Microctonus colesi continued to

be most prevalent; total parasitism for both species at 12 locations ranged from 27% to 57%. Four colonies of M. aethiops were released. Bathyplectes anurus was recovered at most previous release sites but was present in very low numbers.

Studies were begun on soil insects affecting corn in Northern West Virginia. Southern and Northern corn rootworm studies were emphasized.

Title: Insect Pests of Forage Legumes and Grasses

Leader: R. A. Byers, Pasture Research Laboratory, University Park, Pa.

Alfalfa treated with carbofuran granules at 2 lbs ai/acre immediately after seeding at University Park, Pennsylvania and Beltsville, Maryland had 4.8 and 3.0 more plants per linear foot, respectively, than untreated alfalfa at first harvest in July 1973. Alfalfa was 14.9 cm taller at Beltsville in carbofuran treated plots. These same alfalfa plots were treated immediately after first harvest with carbofuran spray at 1 lb ai/acre at University Park and at 2 lbs ai/acre at Beltsville to control potato leafhopper. Alfalfa averaged .2 ton/acre more dry matter/acre, was 37 cm taller, and had .2 ton/acre more digestible forage than untreated alfalfa at University Park. Similar results were obtained at Maryland.

Alfalfa treated with carbofuran granules (1 lb ai/acre) in May 1973 had an average of 1.15 less clover root curculio larvae, Sitona hispidula, per 38 cu in of soil collected from the root zone than soil from untreated alfalfa in Lebanon, Pennsylvania.

Green cloverworm, Plathypena scabra, have been reared through three complete generations on a pinto bean artificial diet.

Alfalfa, red clover, and white clover plants inoculated with Fusarium root rot and also infested with pea aphids, Acyrtosiphon pisum had over two times as much root rot development than plants with either pea aphids or Fusarium alone.

Fox smooth brome grass, Fawn tall fescue, and Redtop produced 1888, 2379, and 1922 kg/ha, respectively, dry matter yields after treatment with carbofuran at 1.12 kg/ha compared to 1297, 1438, 1324 kg/ha for the same grasses left untreated. Carbofuran significantly reduced numbers of meadow spittlebug adults on Masshardy orchardgrass, Clair timothy, Fox brome grass; leafhoppers on Belturf and Kenblue Kentucky bluegrass; and Trigontylus ruficornis on Fawn tall fescue.

SECTION III

PLANT PATHOLOGY RESEARCH

Title: Anthracnose of Forage Legumes

Leader: F. L. Lukezic, Pennsylvania

Anthracnose is becoming a serious problem in the alfalfa-growing areas of central and southern Pennsylvania. This increase in incidence suggests either a change in the pathogen, or shifting environmental conditions which allow increased overwinter survival of the fungus. Field investigations in several areas of Pennsylvania and laboratory investigations were carried out to determine possible reasons for this increase of the disease.

We found that Colletotrichum trifolii can persist from one harvesting season to the next in debris on the surfaces of protected alfalfa harvesting equipment. The fungus was able to survive in alfalfa stems for only 100 days under field conditions. This suggests that under Pennsylvania conditions, infected plants can be important sources of secondary inoculum, but may not be important as a source of primary inoculum. Anthracnose was shown to be important in predisposing the infected plants to winter injury.

Title: Choke Disease Caused by Epichloe typhina Restricted to One Selection of Festuca rubra subsp. rubra

Leaders: R. W. Duell and P. M. Halisky, New Jersey

In a field of 23 vegetatively-propagated selections of spreading fescues (Festuca rubra subsp. rubra) only one strain developed readily discernible stromatic sheaths of Epichloe typhina. Commonly called "choke" or "cattail" disease, the fungus restricted seed production in infected plants. A smooth, dense mass of fungal tissue extended upward from the flag leaf node approximately 2 cm along the sheath, completely surrounding the stem. The inflorescence was aborted or greatly reduced. The collar of the flag leaf was located about 2 mm above the tip of the fungal stromata. Only a withered flag leaf developed. Infected culms constituted up to 50% of the total culms of afflicted plants in the space-planted nursery. All replicates of this selection of F. rubra rubra had infected plants. Some plants, however, contained no evidence of the disease. No other grasses in the nursery appeared to be infected although the literature mentions its occurrence on 26 species of grasses.

Title: Effect of Diseased Alfalfa Forage on Meadow Vole Performance

Leaders: J. S. Shenk, Pennsylvania; K. T. Leath and R. F. Barnes,
Pasture Research Laboratory, University Park, Pa.

The meadow vole was used to assay for antiquality components in diseased alfalfa produced in the greenhouse. Flats of Buffalo or Atlantic alfalfa were diseased separately with rust, *Phoma* leafspot, *Stemphylium* leafspot, *Leptosphaerulina* leafspot or *Pseudopeziza* leafspot. Diseased and healthy plants were harvested, freeze dried, analyzed for major quality components, and fed to weanling voles at 60% of their diet. The rate of weight gain by voles fed *Stemphylium*- and *Phoma*-infected alfalfa was significantly lower than that of voles fed healthy alfalfa. Intake of rusted alfalfa was significantly higher and intake of *Stemphylium*-infected alfalfa was significantly lower than intake of healthy alfalfa. Vole responses could not be explained by the alteration of a single major quality constituent of the plant nor by changes in dry matter digestibility of the forage.

Title: *Fusarium* Root Rot of Alfalfa, Red Clover and White Clovers
Enhanced by Aphid Feeding on Stems and Leaves

Leaders: K. T. Leath and R. A. Byers, Pasture Research Laboratory,
University Park, Pa.

In separate growth chamber tests Saranac alfalfa, Pennscott red clover and Regal white clover were treated as follows: (1) untreated control; (2) upper taproot inoculated with *Fusarium* spp.; (3) leaves and stems infested with pea aphids; and (4) a combination of 2 and 3. Duration of tests was 73 days for alfalfa, 150 days for red clover, and 60 days for white clover. Plants were at least three months old at the start of tests. Root rot scores in the combined aphid-*Fusarium* treatment were significantly higher than those of any other treatment in the alfalfa and white clover tests; with red clover plant-survival days significantly less for the aphid-*Fusarium* treatment than for any other treatments.

Title: A Large Incubation Chamber Suited for Selection of Disease Resistance

Leaders: K. T. Leath and R. R. Hill, Jr., Pasture Research Laboratory, University Park, Pa.

A walk-in chamber for incubating plants during infection by foliar pathogens was designed and constructed. The chamber was adapted from a commercial freezer chamber made of aluminum alloy bonded to urethane-foam insulation. It measures 3.4 m long x 3.4 m wide x 2.0 m high and holds about 5,000 alfalfa seedlings grown in utility carts. Temperature is controlled by flowing thermally regulated water across the sloped floor of the chamber. Saturated humidity is maintained by timed mists and the water-flow cooling system. The chamber has been used successfully to produce leafspot and rust diseases of alfalfa, clover, and grasses. None of the pathogens used required light for infection.

Title: The Interaction of Stemphylium botryosum and Fusarium roseum to Reduce Longevity of Red Clover Plants in the Greenhouse

Leader: K. T. Leath, Pasture Research Laboratory, University Park, Pa.

Two tests were completed with Pennscott red clover plants grown individually in pots in the greenhouse. The treatments used were (1) untreated control; (2) Fusarium inoculation of upper taproot; (3) Stemphylium inoculation of foliage, four times during a period of six months; and (4) a combination of 2 and 3. Tests were terminated when all plants in the Stemphylium-Fusarium treatment were dead. Plant survival days for the combined test results were: Control, 280 days; Fusarium alone, 278 days; Stemphylium alone, 280 days, and Fusarium-Stemphylium combination, 209 days.

Title: New Aspects of Wilt of Alfalfa Caused by Corynebacterium insidiosum

Leader: F. L. Lukezic, Pennsylvania

Isolations from discolored roots of stunted plants with small, pale green leaves consistently yielded green-fluorescent Pseudomonads and Erwinia bacteria; the former were more prevalent. Phenotypic characterizations of representative Pseudomonads are: oxidase and catalase positive, produce levan, lipase, and acid from sucrose. These isolates were unable to hydrolize starch, liquified gelatin, produced pectolytic enzymes, and a green diffusible pigment on King's B medium, which fluoresced blue. These tests indicated that the isolates were close to the Ps. marginalis group. The Erwinias were straight rods, motile with peritrichous flagella, catalase positive, oxidase negative, did not hydrolyse starch or produce lipase or levan, acid was produced from glucose, sucrose, xylose, sorbitol, but not from lactose or rhamnose, metabolism of glucose was fermentative. They reduced NO_3 to NO_2 , liquified gelatin and produced pink diffusible pigment on special media. They are facultative anaerobes and did not produce pectolytic enzymes. These tests suggest the bacteria belong to Dye's E. amylovora group. Laboratory and greenhouse tests indicate the Pseudomonads contribute to plant decline, however, the Erwinias alone did not cause visible symptoms.

Title: Response of *Lolium perenne* to Infection by *Rhizoctonia solani*

Leaders: P. M. Halisky, C. R. Funk and K. J. McVeigh, New Jersey

Sixteen varieties of *Lolium perenne* were evaluated for their response to infection by *Phizoctonia solani* during June, 1973. Periods of high humidity created conditions favorable for disease development. High nitrogen fertility and moderately-poor soil drainage also contributed to the severity of foliar blight and crown rot by *Rhizoctonia solani*. When the incidence of brown patch was severe fungus mycelium grew visibly on the ryegrass foliage. The infection data are shown in the table.

Table 1. Response of Perennial Ryegrass Varieties to Infection by *Rhizoctonia solani*.

Variety	Brown Patch* Rating	Variety	Brown Patch* Rating
Citation	3.0	Manhattan	6.2
Yorktown III	3.3	Splendor	6.3
Turf Seed B	3.3	Game	6.3
Pennfine	3.3	Pelo	6.7
Yorktown II	4.3	NK-100	7.0
Yorktown I	5.0	Barenza	7.7
NK-200	5.0	Caprice	8.0
Sprinter	6.0	Oregon Common	8.4
LSD at 5%			1.4

*Scale of disease: 1 = least; 9 = most

Title: Reaction of Kentucky Bluegrass Varieties to Leaf Infection
by Puccinia poae-nemoralis

Leaders: C. R. Funk, K. J. McVeigh, and P. M. Halisky, New Jersey

In space-planted nurseries of Poa pratensis at Adelphia, New Jersey, yellow leaf rust caused by Puccinia poae-nemoralis occurs commonly during most summers. In 1970 and 1971 moderately-severe epiphytotics occurred during June of each year. The reactions of 32 varieties and selections of Kentucky bluegrass were rated for yellow leaf rust infection on a scale of "0 = no rust to 9 = severe infection." The five most resistant bluegrasses and their respective ratings were: Glade 0.6, Anheuser Dwarf 0.6, NJE P-59 0.7, Nugget 0.7, and Warren's A-20 0.7. In contrast, Merion 3.5, NJE P-7 4.4, and Vantage 7.3 were among the most susceptible entries. The remaining bluegrasses were scored between light infection (1.0) and moderate infection (3.0).

Title: Biological Activities of Saponins from Alfalfa

Leader: K. T. Leath, Pasture Research Laboratory, University Park, Pa.

Cooperators: E. Horber, Kansas; B. Berrang, Research Triangle Institute; V. Marcarian, Michigan; and C. H. Hanson, USDA, ARS, Beltsville, Md.

Ten, relatively pure, saponin fractions from DuPuits and Lahontan alfalfa were assayed for biological activity against the fungus, Trichoderma viride, red blood cells, and leafhopper nymphs. In all assays, saponins from DuPuits showed more activity than did those from Lahontan. Saponins from DuPuits that contained medicagenic acid in their saponogenin structures were the most active in reducing fungal growth, lysing red blood cells, and reducing survival of leafhopper nymphs.

Title: Screening of Smooth Bromegrass Introductions for Resistance to Pyrenophora bromi

Leaders: K. E. Zeiders, R. T. Sherwood, and C. C. Berg, Pasture Research Laboratory, University Park, Pa.

Ninety-eight strains of smooth bromegrass (Bromus inermis Leyss.) were tested for reaction to Pyrenophora (Helminthosporium) bromi (Died). Drechs. by inoculations with conidia. Ninety-three of the entries were accessions (mostly from the USSR and Turkey) obtained from the North Central Plant Introduction Station at Ames, Iowa, and five were US commercial cultivars. On a scale of 1 (no disease) to 5 (very severe) the mean disease severity ratings of 98 entries ranges from 3.2 to 4.1, or from moderately to highly susceptible. No Bromus inermis entry was resistant to H. bromi, but one additional entry (PI 206 264), an annual species (possibly Bromus), was highly resistant (mean = 1.6). The F value for B. inermis extries was not significant at the 0.05 level. However, 174 resistant plants (rating of 2 or less) were selected from among 70 entries. The number of plants selected within each entry ranged from 1 up to 9. There were no resistant plants in 28 of the entries. In a second inoculation the mean disease rating of selected plants was 2.7 while the mean of 21 susceptible plants was 4.4. Polycross seed for the first cycle of recurrent phenotypic selection for resistance to brown leafspot has been produced.

Title: Selecting Resistance to Helminthosporium siccans in Lolium perenne

Leaders: P. M. Halisky, S. J. Han, C. R. Funk, and K. J. McVeigh, New Jersey

Helminthosporium siccans may cause a moderately severe, necrotic browning of the foliage (Brown Blight) of susceptible perennial ryegrass varieties during December-March in New Jersey. The fungus was readily cultured in the laboratory on several types of agar media but failed to sporulate. Results of growth chamber studies indicated that sporulation in H. siccans could be induced by incubating cultures at 50-55 F with supplemental lighting. Using sporulating cultures as a source of inoculum, perennial ryegrass plants were atomized with spores and mycelial fragments of H. siccans. The inoculated plants were incubated at 60-65 F and high humidity in an inoculation chamber for 72 hours. Typical symptoms of brown blight developed after 4-5 days in the greenhouse. Under field conditions foliar browning developed in Lolium perenne during periods of heavy rainfall and

cool temperatures. High nitrogen, poor air circulation and moderately-poor soil drainage appeared to increase the incidence of brown blight. Sixteen varieties of perennial ryegrass were evaluated for their response to infection by H. siccans during December 1972 (Table 1).

Table 1. Response of Perennial Ryegrass Varieties to Infection by Helminthosporium siccans.

Variety	Percent Brown Blight	Variety	Percent Brown Blight
Yorktown I	9	Sprinter	21
Pelo	9	Yorktown III	23
Splendor	10	Turf Seed B	28
Yorktown II	12	NK-100	30
Barenza	13	Game	33
Caprice	14	Oregon Common	35
Manhattan	15	Pennfine	66
NK-200	18	Citation	74
LSD at 5%			11

Title: Sporulation of Leptosphaerulina briosiana

Leaders: B. G. Moyer, Pennsylvania and K. T. Leath, Pasture Research Laboratory, University Park, Pa.

The possible involvement of sterols and P310 sporogenic substances in the sporulation requirement of this fungus for near-UV light was investigated. Various agents were used to block normal sterol metabolism at various stages of fungal development, and sporulating and nonsporulating cultures were assayed for biologically active substances resembling the P310 sporogens reported from other fungi. Ergosterol was identified as the predominant sterol in L. briosiana, but neither sterols nor sporogenic substances were directly involved in the near-UV-light requirement. L. briosiana produced substances resembling P310 sporogens in both light and dark; isolates that did not have a requirement for near-UV light produced more of the P310 substances in the dark than did light-requiring isolates; the production of compounds similar to P310 sporogens seemed more closely associated with the formation of ascostromata than with the actual production of ascospores.

Title: Susceptibility of Five Fescues to Powdery Mildew (Erysiphe graminis) D.C.

Leaders: R. M. Schmit & R. W. Duell, New Jersey

Although powdery mildew is only occasionally detectable in the field in New Jersey (primarily in the fall), it reportedly appears more extensively in the seed producing areas of the Pacific Northwest. Heavy infections could be developed in a cool humid greenhouse under low light conditions, particularly if potted plants were watered at the soil surface so as not to wash conidia from the surface. Three replicates of clones and varieties of 81 fine fescues were established in pots from 10 cm diameter plugs. These consisted of 56 Chewings types, 20 spreading (rhizomatous types), 3 sheep's and 2 hard fescues. Visual ratings of infections were made periodically, and pots were rerandomized twice weekly.

Analyses of variance indicated that only two entries of Chewings types had high levels of mildew resistance, and all others were moderately to extremely susceptible. Only one spreading fescue was susceptible (moderately), and all others were resistant. The hard and sheep's fescues were all rates as intermediate in susceptibility to powdery mildew.

Title: Diseases of Reed Canarygrass

Leaders: K. E. Zeiders and R. T. Sherwood, Pasture Research
Laboratory, University Park, Pa.

Periodic surveys from August 1971 through 1972 and 1973 revealed that reed canarygrass in field plots and nurseries in central Pennsylvania always had little or no disease. However, since August 1972, a leafspot disease (tawny blotch) caused by Stagonospora foliicola was found to be prevalent on reed canarygrass which was irrigated weekly with municipal sewage effluent. It was not observed on plants in the nonirrigated control area. Inoculation tests in a dew chamber at 22 C showed that at least 72 hrs of high humidity was required for maximum infection. Arrhenatherum elatius, Avena sativa, Bromus inermis, Dactylis glomerata, Festuca arundinacea, Lolium perenne, and Phleum pratense were not susceptible to S. foliicola in artificial inoculations.

Twenty-four reed canarygrass clones which varied widely in palatability and total alkaloid content were screened for reaction to S. foliicola. Disease reactions varied from highly resistant to highly susceptible. Disease severity was positively correlated with total alkaloid content, and negatively correlated with relative palatability. This indicates that usually the low alkaloid clones are more resistant to tawny blotch; however, there were exceptions to this association.

Another leafspot disease caused by Helminthosporium catenarium was discovered on both irrigated and nonirrigated reed canarygrass in August 1973. This fungus was not previously known on reed canarygrass. Clones ranged from resistant to very susceptible in artificial inoculations. Some clones appear to have resistance to both S. foliicola and H. catenarium.

SECTION IV

GROWTH, PHYSIOLOGY, AND CLIMATIC EFFECTS

Title: Forage Physiology, Morphology and Growth

Leaders: G. E. Carlson, N. J. Chatterton, R. H. Hart, USDA, ARS,
Beltsville, Md.

After crownvetch-tall fescue stands were clipped every two weeks for six years, 73, 65, and 8 plants per meter square (m^{-2}) of Penngift, Chemung, and Emerald crownvetch, respectively, survived. Chemung was the only variety with fewer plants in plots clipped to 5 cm rather than 10 cm (54 vs. $75m^{-2}$). Penngift, Chemung, and Emerald crownvetch-fescue mixtures yielded as much as fescue without crownvetch, fertilized with 62, 39, and 25 kg/ha of N pure, respectively. Alfalfa clones selected for high yield in simulated solid stands yielded significantly more at spacings of 15, 30, or 60 cm, than those selected for low yield. Individual plant yields were poorly correlated with yields of surrounding plants at all spacings. Many low-yielding plants spaced 15 cm apart died during the year, in populations of all low-yielding plants as well as in mixtures of low- and high-yielding plants.

Work has continued on the identification of physiologic characteristics of plant growth that limit forage production. The naturally occurring changes in the rate of various physiological processes of the intact plants have continued to provide important information on the control systems and therefore, provide possible explanations for growth limitations. We previously reported on diurnal changes in photosynthesis and specific leaf weight and on the inverse relationship of their fluctuations. That data are now substantiated by diurnal patterns for amino acids, soluble and nonsoluble carbohydrates.

Adenosine phosphate energy deficit is related to photoassimilate accumulation and reduced photosynthesis. Diurnal patterns for adenosine phosphates, ATP, ADP, AMP, as well as inorganic phosphates and energy charges, were obtained. The interrelationship of the various components measured demonstrate the role of adenylate energy charge in the modulation of numerous metabolic processes. We hypothesize that the product inhibition of photosynthesis, that is the accumulation of photoassimilates and a concomitant decline in net CO_2 fixation, is the result of an adenylate energy deficit.

Results of our work with sorghum suggest that the reduction in yield obtained from bloomless lines, when grown under dry farm conditions where

water is limiting, is the result of increased transpiration and the resulting less efficient use of the water supply. The bloomless lines do, however, have a higher rate of photosynthesis. Under humid conditions where sufficient water is available that low-water-use-efficiency can be tolerated, bloomless lines may actually yield more than the bloom lines.

A method of pressure calibration has been developed that facilitates routine use of infrared gas analysis for transpiration measurements. In addition to being very sensitive, the system tolerates low flow rates. Furthermore, it permits transpirational measurements on very small leaf areas and/or very low rates of water loss.

Pangolagrass plants grown under elevated CO_2 , 2350 ppm, had significantly greater dry weight, TNC and rate of NCE but significantly less water uptake than plants grown under 320 ppm of CO_2 .

The effects of low concentration of boron on the bioelectric field of hypocotyls from dark-grown mung bean seedlings were manifested only upon exposure of the hypocotyls to red light. Effective concentrations of boron were limited to about 1.0 to 6.0×10^{-7} M. Although earlier results suggested that the boron response appeared to be associated with phytochrome action, subsequent and extensive experimentation has yielded inconclusive results.

Preliminary results indicate that small doses of green light appear to have a rapid effect on the bioelectric field potential. More extensive and repetitive work will be necessary before this unexpected green light effect can be shown to be real and not due to artifact.

Title: Cold Tolerance Studies

Leaders: G. A. Jung and R. R. Hill, Jr., Pasture Research Laboratory, University Park, Pa.; F. H. Witham, Michael Krasnuk, and J. O. Anderson, Pennsylvania.

The effects of applied nitrogen and clipping treatments on winter survival of perennial cool-season grasses were summarized and published. Electrophoretic studies of the relationship of peroxidases, polyphenol oxidase, and indoleacetic acid oxidase to cold tolerance of alfalfa have been completed and a manuscript written. Results with esterase, amylase, peptidase, acid phosphatase, and ATPase are being summarized for publication. Isozyme differences related to cold tolerance were predominately quantitative although some qualitative differences also were observed.

Protein extractants not only affected quantity of protein removed but also number of isozymes, electrophoretic movement of isozymes on gels, and thermal stability of isozymes.

An inheritance study of ATPase and esterase in progeny of cold tolerant and cold sensitive alfalfa plants is underway.

Title: Effects of Slope Exposure on Microclimates and Growth of Grasses and Legumes

Leaders: M. A. Sprague and J. Daddario, New Jersey

A second pyramid was built 37 ft sq by 8 ft high, and with a slope of 27° 10'. It was sodded to ryegrass in March and yields obtained in June, August and September. Sensing devices were installed to monitor soil and air temperature, humidity, soil moisture and rainfall on each of the four slopes. Data were gathered during summer and fall to prepare 3-dimensional profiles for each of the slopes. Winter and spring data are anticipated. Dew observations indicated major differences between slopes under separate circumstances with dew persisting each day on the north slope until noon on clear days and past noon on overcast days. East, south and west slopes experiences different and separate patterns. Incidence of leaf rust on ryegrass followed closely dew persistence patterns. Sod areas on all slopes were killed with paraquat in July and September and seedings made of alfalfa, oats, wheat and rye grains. Measurements of growth and chemical composition of forage are anticipated.

Analyses of orchardgrass samples collected at 10 day intervals in late winter and spring on previously evaluated slopes showed carbohydrate losses closely related to slope exposure and temperature, all of which were separated by about two weeks as spring broke on N and S slopes.

Title: Environmental Studies with Plants

Leaders: A. M. Decker and J. M. Walker, Maryland

Three Pioneer single crosses (C1 x C3, C1 x W2) were grown in field plots at soil temperatures of 16 C, 27 C, 35 C, and ambient. Plots were uniformly fertilized with 224, 99, and 372 kg/ha of N, P, and K, respectively.

Title: Morphology, Physiology and Cultural Response of Perennial Forages

Leaders: J. J. Faix, G. W. Fick, and R. R. Seaney, New York (Cornell)

Iroquois alfalfa and alfalfa seeded with common timothy in the spring of 1972 showed significant difference in plant heaving during the winter and early spring of 1972-73. More heaving occurred where alfalfa was seeded alone (without timothy). However, total seasonal forage yield of the alfalfa-timothy mixture was only about 0.7 metric ton/hectare greater than clear alfalfa. In the alfalfa-grass mixture an early 3-cut harvest system (first cut June 1) resulted in a lower grass percentage than did a late 3-cut harvest system.

The relationship of fall cutting date and taproot TNC levels at the end of the growing season to winter survival and subsequent yields in Iroquois alfalfa was also studied. Two and three cut systems with final cutting dates on September 6, 12, 19, or 26 led to highly significant differences in TNC levels (up to 0.36 MT/ha) in early November 1972. Plant populations in 1973 were significantly lower for plots cut on September 26, 1973, but the date of final cut and fall TNC levels in 1972 had no influence on 1973 yields.

Forage quality was determined for alfalfa grown to early flower stage under 12, 14, 16, 19 and 24 hr daylengths. As daylength increased, plants were taller, less leafy, and younger at early flowering. Stem quality was highest at 24 hr daylength, and lowest at 16 hr daylength. At 12 and 14 hrs greater leafiness compensated for lower quality stems, so whole plant quality was similar under all daylengths except 16 hr, where stem quality was disproportionately low and was not accompanied by compensatory increase in leafiness.

Title: Nonstructural Carbohydrate Studies in Grasses

Leaders: G. A. Jung and C. F. Gross, Pasture Research Laboratory, University Park, Pa.

Cooperator: R. P. Zimmerer, Juniata College, Huntingdon, Pa.

Total nonstructural carbohydrate (TNC), a readily available source of energy, in forage of eight grass species was 55% higher in spring and 64% higher in autumn than in summer. Low TNC values in summer were associated with high night temperatures and abundant moisture. Frosts may have retarded TNC accumulation in May but enhanced TNC accumulation

in October. Perennial ryegrass, timothy, tall fescue and smooth brome-grass forage generally contained high levels and Ky. bluegrass forage contained low levels of TNC. Consistent trends for high or low levels of TNC were observed for cultivars of five species. Timothy and smooth brome-grass produced the most TNC/ha in spring; smooth brome-grass, reed canarygrass, and tall fescue produced the most in summer; and tall fescue and perennial ryegrass produced the most in autumn. Only 60 kg N was required to produce near maximum amounts of TNC each season.

In early spring, Pennfine perennial ryegrass and Masshardy and Pennmead orchardgrass (group 1) had cells with large starch granules, small chloroplasts and relatively less material stored as protein and membranes than did Ky. 31 tall fescue and reed canarygrass (group 2). The studies indicate that group 2 cells apparently convert a higher percentage of photosynthetic product into protein and lipid materials, most of which go into chloroplast and cytoplasm structure. In late spring, a relatively high percentage of photosynthetic product of the group 2 grasses apparently is converted to lipids and is stored in the chloroplasts as lipid bodies. This occurs to a much lesser extent in the group 1 grasses.

Title: Carbohydrate Storage in Ryegrass as Influenced by Fall Management Practices

Leaders: W. Potvin and D. W. Allinson, Connecticut (Storrs)

Ryegrass seedlings were made in the fall of 1972 and 1973. Two cultivars were used, a tetraploid - Tetrelite -, and the diploid common perennial. Nitrogen rates varied from 0 to 100 lb N/acre. The final variable was cutting frequency. A split-split plot design was used. In 1972 samples from all treatment combinations were taken in December and analyzed for total nonstructural carbohydrates (TNC). The tetraploid cultivar had higher levels of TNC than the common perennial. There was no difference in TNC levels in ryegrasses treated with 0 or 50 lb N/acre. Cutting ryegrass frequently, i.e., turf type management, reduced TNC levels compared to a single or zero fall cutting. There was no apparent relationship between TNC levels and winter survival. Tetrelite was extensively (52%) winter killed while the perennial showed only light (10%) winter kill.

Samples from the 1973 seeding were taken in mid January. Again, the Tetrelite had higher levels of TNC compared to the perennial form, i.e., 31.3 versus 21.3%. Fall nitrogen applications depressed TNC accumulation. Winter kill was light, i.e., less than 5%, for both cultivars in 1973-74.

Title: Nutrient Uptake Efficiency of Maize

Leaders: G. O. Estes and J. R. Mitchell, New Hampshire

This project, initiated in 1970, is being reported for the first time to the Pasture Research Laboratory. The two major objectives include characterization of the nutritional status of maize in New Hampshire and assessment of crop physiology as influenced by fertilization practice. Special attention is being devoted to differences in nutrient uptake pattern between cultivars of maize.

Field surveys in New Hampshire showed elemental concentration of Mg in corn tissue to be .25% in 70% of samples. Ear-leaf Mg concentration ranged from 0.04-0.57%. Potassium concentrations were 1.9% K in 91% of the 77 samples analyzed. Hydroponic experiments with corn showed a significant correlation between plant K concentration and $^{14}\text{CO}_2$ uptake. Leaf content of K between 0.75-1.0% was considered critical for 42-day-old maize since $^{14}\text{CO}_2$ fixation was seriously reduced below this concentration.

A differential P-induced Fe stress was noted with two maize cultivars grown in New Hampshire. Fe translocation and utilization differed between Seneca XX155 (Fe-inefficient) and Wisconsin 335A (Fe-efficient) when exposed to increasing concentrations of substrate P. Modest P application sharply reduced Fe uptake in both hydroponic and field experiments. No significant change in Fe status occurred in corn tissue at progressively higher rates of applied P (50-400 Kg/ha) under field conditions. P uptake was significantly correlated with maturity class of maize; short-season cultivars showed higher P concentration in the ear leaf at mid-silk compared to long-season cultivars.

Title: Slant-Board-Culture Methods for Root Growth Studies

Leaders: W. A. Kendall and K. T. Leath, Pasture Research Laboratory, University Park, Pa.

The slant-board system for culturing plants was modified to permit each slant-board to be maintained separately. Each slant-board was fitted with a polyester cloth bag containing perlite and moistened daily with nutrient solution. The individual units increased flexibility of the slant-board culture system, minimized cross contamination with root pathogens, and improved the general sanitation of the system. Several species of legume plants grew to the flowering stage cultured on slant-boards. The procedure has been used to study root growth characteristics, pathogen activity on roots, and disease resistance.

SECTION V

WEED INVESTIGATIONS

Title: An Evaluation of Herbicides for Crabgrass Control in a New Seeding of Alfalfa

Leaders: W. M. Dest, R. A. Peters, and A. C. Triolo, Connecticut (Storrs)

Several new experimental compounds applied on a new spring seedling of alfalfa looked promising for the control of crabgrass (*Digitaria sanguinalis* (L.) Scop.). S-6044 applied at 3 lb/A and 4 lb/A, CGA 10832 at 1 1/2 lb/A and 3 lb/a, A-820 at 1 1/2 lb/A and 3 lb/A, and BAS 3921-H at 1 1/2 lb/A and 3 lb/A gave good to excellent crabgrass control with little or no injury to the alfalfa. EPTC, used as the standard treatment, gave excellent control. Benefin applied at 1 lb/A preplant incorporated and methazole at 2 lb/A preemergence resulted in good control. BAS 3921-H applied at the rate of 3 lb/A and the combination of S-6044 plus alachlor at a rate of 3 lb/A + 1 lb/A moderately injured the alfalfa with a slight reduction in yield. The metribuzin plus benefin combination (1/4 lb/A + 1/2 lb/A) severely injured the alfalfa, reducing yields significantly below all treatments including the check. An increase in alfalfa yield was associated with an increase in crabgrass control.

Title: WEED CONTROL IN PASTURES AND FORAGE CROPS

Leader: D. L. Linscott, USDA, ARS, New York (Cornell)

A metabolite of 2,4-D in grass, 3-(2,4-DP), when applied to grass resulted in a number of metabolites including 2,4-D thus 3-(2,4-DP) is an intermediate and not an end product in 2,4-D metabolism. Grass leaf wax formation was stimulated by 2,4-D but not 3-(2,4-DP). Grass leaf surface constituents removable by rainfall were implicated in loss of applied 2,4-D or 3-(2,4-DP). Residues of MCPA applied at 1.5 and 3.75 lb/A to field timothy and orchardgrass were found at 0.16 and 0.46 ppm in forage and <.10 and 0.54 ppm in hay respectively 21 days after application. In alfalfa stale-seedbed studies, glyphosate was superior to paraquat in controlling weeds and yellow nutsedge. Most effective stage for nutsedge foliage treatment was 20-25 cm. Disking for nutsedge control was as effective as either glyphosate or paraquat. Sublethal dosages of glyphosate in some cases stimulated tuber formation. More tubers

developed under 10-12 hrs light than 14-16 hrs. Glyphosate controlled nutsedge better at 15 and 20 C than at 25 and 30 C. Birdsfoot trefoil and crownvetch established successfully on pasture sites after glyphosate but several troublesome perennial species such as Canada thistle and plaintain were released. Seedling red clover damage was excessive after 4 kg/ha EPTC but not 2 kg/ha. Superior weed control and establishment of red clover and birdsfoot trefoil was obtained after 2 kg/ha of EPTC or benefin followed by 1/2 kg/ha dinoseb.

Title: Chemical Weed Control in Permanent Pastures

Leaders: Daniel E. Brann, Doyle E. Harsh and Barton S. Baker, West Virginia

Two herbicides, 2,4-D and dicamba, were applied alone and in various combinations to areas in permanent pastures infested with Canada thistle and/or horsenettle. Three locations representing three climatic conditions and three soils were used to evaluate results. Applications were made in either fall or spring. Dicamba killed all legumes (mostly alfalfa and white clover) at lower concentrations than necessary to kill weeds. 2,4-D at 1.5 lb/A reduced horsenettle and thistle populations by 90% without significant damage to legumes. Two pounds of 2,4-D per acre reduced legumes in the sward by 50% or more. There appeared to be little difference in response among locations.

Title: Annual Weed Control in Field Corn

Leaders: W. M. Dest, R. A. Peters, and A. C. Triolo, Connecticut (Storrs)

Herbicides were applied alone and in combinations for evaluation of annual weed control in field corn. The dominant weed species was large crabgrass (*Digitaria sanguinalis* (L.) Scop.). All the pre-emergence herbicide treatments tested except dicamba and NIA 21844 at 1/2 lb/A gave good to excellent crabgrass control early in the season. Alachlor in combination with simazine, simazine + atrazine, cyanazine, dicamba, chloropropham, or metribuzin provided season long control of crabgrass. Simazine 80W at 3 lb/A, Bay Kue 2236, and AC 92553 + atrazine 80W also gave good control over the duration of the growing season.

Postemergence treatments resulted in very poor control of crabgrass. Both the 80W and 4L formulations of cyanazine applied postemergence injured the corn. The more severe injury resulted from the 4L formulation.

Butylate + atrazine (3 + 1 lb/A), EPTC + atrazine (3 + 1 lb/A), and vernolate + atrazine (3 + 1 lb/A) applied preplant incorporated gave full season control of crabgrass. Atrazine added to CGA 10832 increased herbicidal activity but did not result in crabgrass control over the duration of the growing season. All other herbicides applied preplant incorporated gave good control initially but failed to maintain crabgrass control through the growing season.

SECTION VI

MANAGEMENT AND PRODUCTION RESEARCH

Title: Improvement of Alfalfa Forage Quality and Yield for Dehydration

Leaders: J. B. Washko and F. L. Lukezic, Pennsylvania

Dry matter production ranged from 2.05 to 2.73 tons per acre in the seedling year when 28 alfalfa varieties were spring seeded on a prepared seedbed treated for chemical weed control. Only four varieties, Beltsville 71, WL305, WL311, and Titan, showed a high degree of resistance to the disease, Anthracnose, that has been responsible for loss of stands and yield deterioration in that region. Beltsville 71 showed the lowest incidence of this disease. These data indicate that dehydrators should select anthracnose resistant varieties with a high yield potential to maximize returns from their alfalfa crop.

Alfalfa grown on a Washington silt loam soil in the Lehigh Valley failed to respond to different phosphorus and potassium levels in the seeding year, and potassium source (muriate of potash vs. sulfate of potash) had no effect on forage production. No yield response was obtained the year after seeding to lime coating of alfalfa seed on a soil with a pH of 6.6.

Title: The Response of Alfalfa to Fertility, Irrigation, and Cutting Management

Leaders: N. A. Clark and J. H. McNemar, Maryland

Alfalfa varietal improvement has made significant progress in recent years, but alfalfa management practices in Maryland have not changed in the last 15 years. Since that time, in addition to improved varieties which have come on the scene, fertilizer recommendations have changed.

An experiment was established in the fall of 1973 to compare, in terms of yield and stand persistence, a reliable old alfalfa variety with a popular new variety under: irrigated and nonirrigated conditions, current soil test fertilizer recommendations and a rate twice this amount, and several levels of intensity in cutting management. An objective is also to compare yield productivity with nutrient digestibility under the several management systems. The first harvests are being made in the 1974 growing season.

Title: Reseeding Alfalfa in Winter-Injured Stands

Leaders: C. S. Brown and R. F. Stafford, Maine

The overseeding treatments initiated in spring 1972 (1972 Annual Report, p. 47) continued to be evaluated in 1973. Three harvests were made during the 1973 season, and yields of component species were determined. Yields of alfalfa dry matter ranged from 2.60 to 3.80 tons per acre in plots previously overseeded with a packer (Brillion) seeder, in contrast to 0.07 to 0.38 tons in the untreated checks. These results confirm those of previous studies which show the effectiveness of direct overseeding of alfalfa into young, relatively grass-free stands which have been partially or fully winterkilled.

Title: Summer Seeding Dates for Alfalfa

Leaders: C. S. Brown and R. F. Stafford, Maine

A seeding date study, initiated in August-September 1972 with a mixture of Iroquois alfalfa and Climax timothy, was evaluated under a 3-cut harvest system in 1973. Alfalfa dry matter yields ranged from 0.38 tons from a September 7 seeding to 2.28 tons from an August 7 seeding. Yields of the associated timothy were less affected by delayed planting, ranging from 1.57 tons for the September 7 to 2.06 tons for the August 7 seeding.

A new seeding date study was initiated in 1973, with dates ranging from August 9 to September 11. Striking differences in fall growth were observed in response to declining daylength and cooler temperatures. In spring 1974 virtually no survival of alfalfa was observed in the September-seeded plots, in contrast to vigorous growth of alfalfa in the August-sown plots. These results, coupled with those of the 1972 seeding, indicate the rapid decline in seedling growth rate of alfalfa which occurs after mid-August in northern climatic zones.

Title: Establishment and Management of Several Grass and Other Species for Forage and Ground Cover

Leader: J. B. Washko, Pennsylvania

Three seeding implements embodying different seeding techniques, a packer wheel drill, the Nesbit grass drill and a corrugated roller-seeder, were compared for establishment of the flat pea and the following warm season grasses, NY-1325 deertongue, Blackwell switchgrass, NY-1145 big bluestem,

Aldous little bluestem, and Oto Indiangrass. The only species that was successfully established was the switchgrass. Most satisfactory switchgrass stands were obtained with the packer-wheel and Nesbit grass drills. A contributing factor to seeding failure was competition from pigweed. Chemical weed control for pigweed could not be applied because of the random distribution of the flat pea which would suffer chemical injury.

Stands of flat pea, deertongue and switchgrass from a July 1972 seeding (delayed by hurricane Agnes) winterkilled during the 1972-73 winter.

This suggests that date of seeding may be a critical factor in establishment of these species. They cannot be seeded too early in the spring because their seeds will not germinate until soil temperatures are quite high and stands from mid-summer seedings winter-kill due to insufficient plant development prior to winter.

Title: Introduction of a Legume into a Vigorous Long-Lived Stand of Bromegrass (Bromus inermis)

Leader: V. Ulrich, West Virginia

A vigorous 14-year-old stand of bromegrass that had been utilized for both pasture and hay production was reseeded with Saranac alfalfa on March 24, 1973 in order to improve forage quality and to establish effective seeding rates for reintroduction of the legume into an established grass stand. The stand was cleared of the previous years grass by burning in all areas where it had not been grazed off the previous fall. The seeding rates used were 0, 10, 15, 20, 25 and 30 lb/acre. Various ratios of phosphate and potash fertilizer were also applied.

Germination and seedling growth were excellent, however, the vigorous regrowth of the bromegrass in spite of the lack of applied nitrogen fertilizer necessitated harvesting of the bromegrass in early June at anthesis in order to reduce the severe competition. The yield for areas previously utilized for hay was 2.04 tons/acre. The areas that had been utilized each year for pasturing by sheep of the second, third and fourth regrowth yielded 2.52 tons/acre (13% moisture).

Plant counts were made in all plots in November. Although these data await the completion of statistical analysis it is quite apparent that the 10 lb/acre seeding rate is clearly inadequate for both hay and pasture treatments. The 15 lb/acre seeding rate was variably successful in reestablishment of the legume. The 20, 25, and 30 lb of seed/acre were all effective in establishing a satisfactory stand of alfalfa. The plant count revealed no differences between these rates in the hay management plots.

The plant counts in the pasture management section were all decidedly lower at every seeding rate to the counts in the hay management

sections. Although initial establishment of the alfalfa, with respect to germination and seedling growth was the same, the more vigorous growth of the brome grass resulting from manuring effects provided very severe competition for seedlings in spite of the June harvest. Regrowth of the grass was also quite vigorous thereafter. A second harvest of the grass at the 4-inch mower blade height 4 weeks or so after the first cutting may possibly have reduced competition and improved plant count numbers of alfalfa. It must, however, be emphasized at this point that the higher seeding rates of 20, 25, and 30 lb/acre resulted in the establishment of at least one vigorous alfalfa plant per square foot in some of the replications.

The efficacy in improving protein content of the forage awaits the 1974 growing season's growth and harvest.

Title: Evaluation of Perennial Ryegrass and Ryegrass-Tall Fescue Hybrids as Forage for Northern Areas

Leaders: Glen M. Wood and James G. Welch, Vermont

Nineteen perennial ryegrasses, 1 tall fescue (Kentucky-31), and 8 tall fescue-ryegrass hybrids were compared under a 4-cut management (see 1972 Annual Report, p. 24). Summer injury (heat drought), rather than cold injury, was critical to the survival of most of the ryegrasses. All ryegrasses (Manhattan, Combi, Melle, Splendor, Barenza, Caprice, Norlea, NK-100, NK-200, Epic, Common and several experimentals) except Pennfine, suffered severe heat and drought injury during the summer of 1973. All surviving hybrids (most winter-killed the first winter) and Ky-31 tall fescue tolerated the summer conditions without injury. Subsequently all grasses not weakened by summer injury survived the test winter of 1973-74. These were: Pennfine perennial ryegrass, Ky-31 tall fescue and hybrids Kenhy (from the Kentucky Experiment Station) and Syn M and Syn G (from the U.S. Regional Pasture Research Laboratory).

Kenhy produced the greatest yield of dry matter, followed by Syn G, Syn M, and Ky-31 tall fescue in that order. Pennfine perennial ryegrass produced 57% as much dry matter as did the tall fescue-ryegrass hybrid Kenhy. Pennfine was highest in average percentage of in vitro digestibility (81.4) followed by Ky-31 (79.1), Kenhy (78.7), Syn M (73.4), and Syn G (73.0).

Title: Minimum Tillage Pasture Renovation

Leaders: A. M. Decker, H. W. Everett, and R. F. Dudley, Maryland

Several sod-seeding methods were tested in the renovation of a predominantly bluegrass pasture. Four soil openers, two seed placement units, and two chemicals were evaluated. All treatments were limed and fertilized except one of two check treatments. All treatments were applied in the spring and fall; thus, the field design was a split plot (whole plot seeding date) with four replications.

Paraquat (0.5 lb/acre) produced more rapid grass kill than Glyphosate (1.5 lb/acre); however, sod kill lasted longer with the latter. In addition to longer residual sod control with Glyphosate, some troublesome perennial weeds were also eliminated.

No real difference was found among soil openers; however, the double disk seed placement unit resulted in consistently better establishment.

The unfertilized check plot produced substantially less forage than any other treatment. Volunteer white clover increased with fertilizer application, chemical treatment of the sod, and mechanical destruction of the sod. Thus, the pasture sward was improved even where stands of the sod-seeded legume were weak.

Title: Influence of Summer Cutting Managements and Fertilization on the Fall Growth and Composition of Ky 31 Tall Fescue

Leaders: J. A. Balasko and Michael Collins, West Virginia

Studies are being conducted to determine the effect of N, P, and K fertilization and summer cutting schedules on the yield and quality of Ky 31 tall fescue harvested in winter.

In one experiment N, P, and K are applied in factorial combinations. N is applied at the rate of 60 kg/ha in spring and after each summer cutting and P and K are applied at the rate of 30 and 60 kg/ha respectively in spring and fall. Three summer cuts are taken, and winter harvests are made in mid-December and mid-January. Delaying harvest from mid-December and mid-January significantly reduced dry matter yield, crude protein, and N, P, K, and Mg concentrations. N fertilization more than doubled seasonal dry matter yield whereas P and K had little effect on yield.

In a second experiment, initiated in 1972, N fertilizer is applied to plots at three rates (60, 120, and 180 kg/ha) in split application in early spring and in August. Plots are cut according to three summer-winter schedules. These are: (1) cut in mid-May and in early July

and then in mid-December, mid-January, or mid-February, (2) cut in early June, in mid-July and then in mid-December, mid-January, or mid-February, and (3) cut in mid-June and then in mid-December, mid-January, or mid-February. Taking two summer cuttings rather than one before allowing fescue to accumulate for winter significantly increased annual dry matter yield and did not significantly reduce winter yield. The combination of high N (180 kg/ha) and taking only one summer cut in mid-June significantly reduced stand in only 1 year. Quality components being measured in this study include crude protein, IVDMD and mineral concentrations.

Title: Productivity and Quality of Fertilized Perennial Forages

Leader: L. F. Marriott, Pennsylvania

Application of various rates and combinations of P, K and Mg to a 1970 seeding of crownvetch resulted in no differential response in 2 cuts in 1973. Cutting management included harvest at beginning bloom (6/15) and at full bloom (7/3), with the second harvest 10 weeks later in each case. There was no difference in total yield between the earlier and later harvest schedules. However, the average percentage of N in the forage harvested 6/15 was 3.3 while that in the 7/3 forage was 2.6. There was no difference in percentage of N in the second cut forage (3.5%).

The 1972 seeding of orchardgrass, brome grass, timothy and tall fescue alone and with crownvetch in association resulted in an excellent stand of the grasses but very little crownvetch. Yield and nitrogen removal data suggest some contribution by crownvetch in the orchardgrass association and a lesser effect in the other associations. From comparisons with results from nitrogen applications, it appears that as an average, the crownvetch effect was about equivalent to 50 lb N on the grasses. Crownvetch seeded alone in 1972 resulted in a very thin stand with little growth. No harvest was made. Alfalfa seeded alone in 1972 showed no differential response to fall applied P and K treatments.

Orchardgrass, brome grass, timothy and tall fescue seeded in established crownvetch in 1972 showed their ability to compete by the fact that at the first harvest in June, 1/2 to 2/3 of the harvested forage was grass.

Title: Potassium Stress Effects in Corn

Leaders: D. W. Koch and G. O. Estes, New Hampshire

Corn was grown hydroponically in the greenhouse in order to determine the influence of K stress on growth, CO₂ assimilation and stomatal response. Progressively higher levels of leaf K were obtained by growing plants in substrates ranging from 0 to 9 mM K/liter. Critical leaf K concentration was found to be 0.75 to 1.0% for the youngest fully-expanded leaves at 42 days. Below this level net CO₂ uptake was greatly reduced.

In a subsequent experiment, corn grown at 0.50 mM K/liter compared to 3.0 mM K/liter had a higher stomatal resistance of youngest fully-expanded leaves at 30, 47, and 62 days after emergence. K-stressed (0.50 mM/liter) plants had a larger gradient in K level from lower to upper portions of plants than K-adequate plants. Lower tissue K levels did not affect stomatal frequency. Visible deficiency did not occur in leaves measured of either K treatment. Specific leaf weight in all measurements was higher for leaves containing higher levels of K.

SECTION VII
ENGINEERING RESEARCH

Title: Regional Project NE-70 -- Engineering Systems for Forage Crop Production and Use

Leaders: W. L. Kjelgaard (Pa), Chairman, Research Committee; G. F. Rehugler (NY); R. J. Rowe (Me); D. R. Mears (NJ); and L. F. Whitney (Mass).

Contributors: The Maine, Massachusetts, New Jersey and Pennsylvania Agricultural Experiment Stations.

A simulation model is being developed to predict the influence of weather patterns at harvest time on the performance of a given forage management system (NJ).

A flow chart of machine alternatives for harvesting, processing, and storage of forages was prepared. All mechanical activities of the system were evaluated in terms of their energy requirements. From this forage flow system, organized for linear programming solutions, factors of mechanical energy relationships can be resolved. The model facilitates evaluation of energy input or fuel needs for forage production systems (Pa).

A preliminary analysis of a proposed system for producing "dried grass" as concentrate replacement in feeds was conducted. The system included harvest and transport of chopped forage, continuous flow drying followed by wafering or grinding and pelleting. Three variable factors were: field drying, dryer thermal efficiency and fixed cost of drying equipment. Production costs to the point of storage ranged from \$39 to \$71 per ton. Compared with current dairy concentrate prices, a margin of 10 to 30 dollars a ton favoring "dried grass" indicates the economic potential for the product (Me).

A laboratory scale chain-conveyor column drier (with cross-flow air similar to grain driers) was developed and tested with chopped forage. Results showed satisfactory handling and drying and the suitability of the cross-flow dryer configuration for chopped forage (Me).

Work continued on wet extraction of plant protein from forage as a direct food or feed protein source (Mass). Research is being conducted to concentrate and purify the expressed juice using ultrafiltration. Other research is concerned with cell wall breakdown to facilitate release of liquid extract and properties of the suspension. The test results will be used to estimate power requirements and feasibility for scaled-up processing models such as evaporation and spray drying.

Engineering analysis of the circular dairy barn with self-feeding silo continued (NJ). In general, feeding, liquid manure, and ventilation systems are satisfactory. Design changes are being proposed for the air conditioning system.

Title: Engineering Systems for Immature Forages

Leader: R. J. Rowe, Maine

A preliminary analysis was made of a system for producing high protein-high energy concentrate replacement feeds from young forages. The basic system considered was harvest and transport of grass or legume crops as chopped forage, drying in a continuous flow dryer followed by wafering or grinding and pelleting prior to transport and storage. With product value based on dairy concentrate prices, considerable economic potential was indicated.

A field demonstration project was conducted to show the feasibility of producing a forage-concentrate feed in Maine. Forage samples obtained will be evaluated by chemical analysis and feed trials.

Active planning is now underway for an interdisciplinary project to evaluate a production system for forage-concentrate adapted to Maine conditions. Work planned for next year includes development of a pilot system of harvest and drying to produce sufficient product for feeding trials.

Title: Engineering System of Forage Crop Production and Use

Leaders: L. F. Whitney and C. S. Chen, Massachusetts

The study of the basic mechanics of rupture of the plant cells for maximum release of protein has been completed and a design prepared for a machine to accomplish the highest protein yield from alfalfa with a minimum of power. Stages of maturity in terms of days of growth seem to differ from that recommended heretofore. Previous acceptance of alfalfa leaf protein as human food has been limited by its green color and bitter taste. Mechanically expressed liquids of mascerated alfalfa plants have been fractionated by ultra filtration using membranes which separate substrates of different molecular weight, which resulted in the removal of the bitter taste and the chloroplasts without denaturing the protein or reducing its availability for human nutrition.

Title: Engineering Systems for Forage Crop Production and Use

Leader: David R. Mears, New Jersey

During the spring of 1973, an additional 8 ft ring was added to the top of the silo on the Circular Dairy Barn, increasing its storage capacity. This should enable the animals to be fed completely through the winter without running out of feed in the spring. Unfortunately forage produced in the fall of this year did not completely fill the silo with its extended capacity. The liquid manure system continues to work well. Since the last modifications to this system in June 1971, it has not been necessary to do anything other than maintain the flushing schedule. The ventilation system continues to work well. Data collected relating to the effectiveness of the system under various temperature and humidity conditions are being analyzed. Development of mathematical models for forage systems has continued in two phases. The first is an extension of the linear programming model previously developed to include the numbers of each of several different types of machinery used as a decision variable rather than as a fixed resource, thereby enabling selection of the machinery needed for optimum production plan. The second phase is the development of a simulation model to determine the performance of any given management system as determined by weather patterns at harvest time. This model should overcome one of the major limitations of the linear model which depends upon certain determined weather patterns being established before a solution is computed.

Title: Engineering Systems for Forage Crop Production and Use

Leaders: W. L. Kjelgaard, Pennsylvania

From analysis of models the daily capacity (ton) and energy inputs (hp-hr/ton) for the handling and transport of forage materials from field into storage have been determined. Variable factors were harvesting rate (ton/hr), one-way haul distance and type of handling or transport device. When haul distance (0.5 to 2 mi) and harvesting rates were averaged, the typical results show:

<u>Forage material</u>	<u>Number and type handling machine</u>	<u>Average handling rate</u> (ton/hr)	<u>Average energy use</u> (hp-hr/ton)
Corn silage	2 Box wagons	16.5	2.4
" "	2 Forage wagons (self-unload)	22.5	2.7
" "	2 Box trucks	30.5	1.8
Hay bales*	3 Rack wagons and bale thrower	5.0	7.7
" "	3 flat wagons and bale chute	6.0	5.7
" "	2 PTO-Auto bale wagon	6.5	5.9

*Bale density = 9.2 lb/ft^3 .

Energy use per ton of dry matter, assuming hay 15% and corn silage 65% moisture, averaged 7.5 hp-hr/ton for baled hay and 6.6 hp-hr/ton for corn silage. For corn silage transport trucks used 25% less energy than tractors and wagons.

Title: Circular Dairy Barn

Leaders: M. E. Singley, David R. Mears, and Willaim J. Roberts,
New Jersey

During the spring of 1973, an additional 8 ft ring was added to the top of the silo on the Circular Dairy Barn, increasing its storage capacity. This should enable the animals to be fed completely through the winter without running out of feed in the spring. Unfortunately, forage produced in the fall of this year did not completely fill the silo with its extended capacity. The liquid manure system continues to work well. Since the last modifications to this system in June 1971, it has not been necessary to do anything other than maintain the flushing schedule. The ventilation system continues to work well. Data collected relating to the effectiveness of the system under various temperature and humidity conditions are being analyzed.

SECTION VIII

NUTRITIVE EVALUATION AND UTILIZATION

Title: Regional Project NE-24, The Nutritive Evaluation of Forages

Leader: D. R. Waldo, USDA-ARS, Beltsville, Md., Chairman, Regional Research Committee

Experiment stations and other agencies with contributing projects:

The Connecticut (Storrs), Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Vermont, and West Virginia Agricultural Experiment Stations; the U.S. Regional Pasture Research Laboratory, ARS-USDA, University Park, Pa.; and the Ruminant Nutrition Laboratory, ARS-USDA, Beltsville, Md.

Other cooperating agencies: Cooperative State Research Service, ARS-USDA

The objective of the NE-24 regional project is to determine the basic factors controlling the intake of rations based on forages. The contributing projects considered the physical and chemical properties of the ration and the physiological status of the animals relative to intake. Some agronomic factors that may affect chemical composition of forages and intake were considered.

The limitation of the ruminant GI tract capacity is one of volume and not mass. Expressions of ration density require some sort of volume measurement. Four methods of density measurement are being considered (Pa.). Bulk densities are measured in either a 500 ml graduated cylinder or a 1 cu. ft box, and solid densities are measured in either a Beckman pycnometer or a special 0.51 cu. ft large pycnometer. The larger devices for each density use rations as fed and the smaller use rations ground to 1 mm. Bulk densities magnified differences relative to solid densities. Bulk densities of mixed rations were highly correlated with the weighted sum of individual ingredient fractions ($r = 0.94$). Theoretically, a bulk density, as fed, should be most predictive and this was true last year using sheep data (Pa.). This year the bulk density (1 mm) grind was slightly more predictive using milking cow data (Md.) so the question of the best and most general density measurement is not yet resolved. The time spent eating was inversely correlated with DE ($r = -0.96$) and with bulk density ($r = 0.73$) (Pa.). Rate of feed consumption was correlated with DE ($r = 0.99$) and bulk density ($r = -0.93$). The rate of eating, g/min, and eating times, minutes, increased as individual meal size increased.

The influence of the physiological state of the animal on the prediction of caloric intake from caloric density was studied using wethers and lactating ewes (Pa.) and lactating cattle (Md.). For the rations having a bulk density, as fed, greater than about 0.8 to 0.9 Kcal/ml the daily Kcal DE/kg^{3/4} were: wethers, 275; lactating cattle, 375 and lactating ewes, 400. For rations with lower caloric densities the intake declined as caloric density declined. But at these lower densities the rations were consumed in greater amounts by the lactating animals than by the wethers. In these rations, where caloric density was primarily changed by increasing concentrates, the caloric density at which intake was no longer increased by increasing caloric density was very similar for animals with different physiological need. One must question whether this point is as constant if caloric density is varied primarily by digestibility differences in the same forage species.

The effect of moisture on intake was investigated. Fresh corn was chopped, frozen and dried to 66, 43, 21 and 0% water (Md.). Dry matter intake and digestibility were not affected but heat production by respiration calorimetry was slightly greater for the 0% diet. In forage rations that varied in moisture, fermentation products and probably bulk density, the percentage dry matter and g daily dry matter intake per kg^{3/4} were: direct cut silage, 25, 75; dried silage, 93, 71; hay, 88, 79; rewetted hay, 25, 88; formaldehyde-formic acid silage, 21, 70 and wilted silage 51, 83 (Pa.).

Particle size reduction is a necessary part of rumen digestion in order for ingested forage particles to pass from the rumen (Vt.). Ten cm forage stems placed in nylon bags in the rumen underwent minimal particle size reduction from microbial action alone. Masks preventing rumination for 20 hr daily reduced intake to less than 60% of normal and several days were required for intake to return to normal upon removal of the masks. Inert polyethylene glycol 400 stopped rumination at 350 mOsm as had salt solutions. Increasing rumen pH above 7.5 stopped rumination as observed previously for pH's below 5.5.

Last year a fiber digestion model was proposed that split the chemical fiber fractions of ruminant feeds into two fractions based on in vitro microbial fermentations. In vivo the two fractions were considered either undigestible, which can only pass from the rumen, or theoretically digestible which can be digested or pass from the rumen. The rate of digestion and the microbial splitting of fractions were based on a plot of the log of undigested residue as a function of time. The asymptotic fraction remaining was considered indigestible. Subsequent interpretations of in vitro fermentations have considered it more appropriate to plot both axes as reciprocals (N.Y.). The reciprocal of the undigested residue is a linear function of a reciprocal of time. The intercept at zero reciprocal of time is a reciprocal of the undigestible fraction. The rate is derived from the slope of the line. At low daily dry matter intakes, daily fecal output was reduced, which points toward the rumen rather than the intestine as limiting intake (N.Y.). Digestibility depression at production levels of feeding leaves most tabulated data seriously overestimating digestibility (Md., Pa.). This contributes to a reduced intake of digestible matter. Most of this reduction occurs in the fiber fraction

(N.Y.). This decline results partly from the reduced retention time in the rumen which reduces the extent of digestion (N.Y.). Changes in digestion rate may also occur.

Chemical properties of forage based rations considered were insoluble and soluble carbohydrates, nitrogen form and minerals. Acid detergent fiber was extracted with sodium hydroxide to give soluble lignin from tall fescue and bromegrass with in vivo dry matter digestibilities from 52 to 74 and 47 to 73%, respectively (Conn.). As bromegrass matured, accompanied by an increase in acid detergent lignin from 2.5-7.0%, direct absorbance values in NaOH at all wavelength readings increased. The lignin spectra in immature bromegrass were typified by a shoulder beginning at 260 m μ with a slight peak at 290 m μ . As the bromegrass matured the direct lignin spectra contained definite peaks at 290 m μ with a valley at 260 m μ . The direct peak absorbance values at 290 m μ were positively correlated with ADL values. Difference spectra (Base A-Acid A) for immature bromegrass lignin had a valley at 250 m μ with a single peak at 300 m μ . With increasing maturity a second difference peak at 340-350 m μ became evident. Spectra of tall fescue were similar to those for bromegrass. The tannin concentration was higher in tropical legumes than grasses (W.Va.). There was considerable variation due to species. High tannin concentrations were related to lower forage intakes and bloat susceptibility.

In vitro cellulose and ammonia production rates were determined on timothy and reed canarygrass (Me.). At 21 hr cellulose digestion was correlated with total soluble N ($r = 0.69$), soluble free amino acids ($r = 0.69$) and insoluble N ($r = 0.72$). Grasses which had been N fertilized, had a higher rate of cellulose digestion at later time periods. Supplementation of a urea-corn silage containing 2.2% N with additional urea increased intake, steer gain and nitrogen retention (N.J.). Intake decreased when plasma ammonia rose to 345 μ g/100 ml. Equal nitrogen retention required 26% more dietary nitrogen as soluble than insoluble. When raising crude protein equivalent of corn green chop from 8.6 to 12.1, 15.6 or 19.1 with urea, an equalized forage intake increased volatile bases in rumen fluid but decreased dissolved magnesium (Mass.). Adding urea to 15.6% CP increased total VFA concentrations and proportions of propionic and n-butyric but decreased that of acetic. Dissolved sodium, potassium, calcium and pH were not consistently affected. For 84 days prepartum cows were fed 24 vs. 157 g Ca/cow/day compared to a NRC recommendation of 37 (N.J.). Splitting each prepartum group for 84 days postpartum they were fed 37 vs. 239 g compared to a recommendation of 104. High postpartum Ca increased intake at 14 and 84 days (15.4 vs. 17.6 kg/cow/day). Prepartum Ca seemed to affect intake yet at 84 days (17.2 vs. 19.9). Treatment effects on serum Ca and milk production were similar to those on intake. Magnesium and phosphorus balances remained positive at the high Ca intakes.

Physiological metabolites in crownvetch received further study (Pasture Lab). Ensiling or weathering reduced the adverse responses of low intake, slight incoordination, weight loss and often death observed in weanling meadow voles. One of a group of compounds isolated by extraction and thin layer chromatography has been crystalized. Other species have been fed crownvetch. Mature voles survived. Growing chicks fed 20% crownvetch had nervous disorders, reduced growth and often died. Laying hens had no nervous symptoms but showed poor feed intake and

ceased egg production. Mature sheep showed only lower intake. Reed canary-grass intake by voles was inversely related to alkaloids as previously observed for sheep. Alfalfa with up to 25% diseased tissue from either Lepto, Phoma or common leafspots, target spot or rust did not differ in chemical composition, in vitro digestibility or intakes. But vole gain was lowered by Phoma leafspot and target spot.

Title: The Nutritive Evaluation of Forages

Leader: James G. Welch, Vermont

Factors controlling voluntary intake of forages are being determined. Particle size decline of selected hay stems was measured by placing 10 cm length pieces in nylon bags and submerging them in the rumens of fistulated steers. During 10 days some particle size decline was observed in all but the reed canarygrass stems. In no case was the particle size decline sufficient to allow for the passage of the total sample from the rumen indicating that microbial digestion of high fiber particles is not sufficient to allow for passage. The rumination potential of CWC in haylage and corn silage was measured. Results were highly variable due to high variation in intake levels. Steers fitted with face masks to prevent rumination for 20 hr per day consumed less than 60% of their normal intake within 3 days. When the masks treatment was stopped intake did not return to normal for several days. Fistulated steers were emptied and then refilled with chopped hay mixed with water to approximate the water content of the ingesta removed. Upon refilling with the wet chopped hay, rumination commenced within 1 hr in both treated steers. Polyethylene glycol 400 was used as an inert soluble material for changing the osmotic pressure of rumen contents. The critical level of 350 mOsm. was affirmed with this material. Previous measurements with mineral salts indicated that osmotic pressures above this level caused a cessation of rumination.

Changing rumen pH to the basic range with 0.08 N NaOH to above pH 7.5 caused a cessation in rumination. Osmotic pressure did not rise above the critical 350 mOsm. level. Data continue to accumulate that rumination efficiency is not associated with metabolic body size in immature animals but is much lower in less mature ruminants.

Title: Nutritive Evaluation of Forages (Grazing Trials with Sheep and Cattle)

Leaders: R. L. Reid and J. A. Balasko, West Virginia

Replicated pastures of perennial ryegrass (Pennfine), smooth brome (Sac), orchardgrass (Potomac) and tall fescue (Ky 31) were established in 1972

and grazed by combinations of sheep and cattle in 1973 and 1974. Main criteria of quality were weight gains, digestibility and intake (determined with cut herbage at different growth stages, and with grazing lambs using fecal N-chromic oxide techniques), mineral balance and serum mineral levels. Yearling steers at a set stocking rate were used in 1973, cow-calf units at a variable stocking rate in 1974. Data indicate differences in DDM and intake between forage species when harvested at the same time. Weight gains tended to reflect differences in intake of DDM. Both lambs and steers showed poorer performance on tall fescue over the spring-fall period in 1973; with lambs, season weight gains on fescue were significantly lower than on other grasses, with cattle they were not. Analytical studies are in progress to relate composition of forage to nutritional properties.

Title: The Comparative Value of Penngift Crownvetch as a Forage for Ruminants

Leaders: T. A. Long, A. D. Peterson, L. L. Wilson, M. L. Risius, and J. E. Baylor, Pennsylvania

In an experiment conducted in 1971, crownvetch and alfalfa were harvested at late-bud and full-bloom maturity stages, preserved as hay and haylage, and fed to crossbred wethers to determine apparent digestibility of dry matter, energy, and protein as well as voluntary animal intake. The apparent dry matter digestibilities of alfalfa and crownvetch were about the same. The dry matter digestibility decreased from the late-bud to the full-bloom maturity stage. Preservation as haylage also produced a decrease in digestibility. At full bloom, the digestible energy of alfalfa was higher than that of crownvetch, but both forages were similar at late bud. Digestible protein for crownvetch was greater at both maturity stages. Intake of crownvetch relative to alfalfa depended upon the preservation method and stage of maturity. Consumption of crownvetch and alfalfa hay was about the same when the forage was harvested at full bloom. However, more alfalfa than crownvetch was consumed when both were harvested at the late-bud maturity stage. When preserved as haylage, intake was greater for alfalfa harvested at full bloom, but intake of crownvetch was similar to that of alfalfa when both were harvested at late bud.

Title: Control of Feed Intake and the Regulation of Energy Balance in Monogastric and Ruminant Animals

Leader: P. J. Wangsness, Pennsylvania

Feeding behavior was studied in eight sheep individually housed in feeding behavior units. A complete ration of 20% chopped hay and 80% concentrate was used. Parameters measured on 1877 individual meals included meal size, meal duration and eating rate. Respective means were 135.2 ± 1.9 g, 12.6 ± 0.2 min., and 11.7 ± 0.1 g/min. To help detect changes in these parameters with different meal size, meals were grouped into the following subclasses: <50, 50-100, 150-200, 200-250, 250-300, 300-350, and >350 g. Respective eating rates were 7.5, 11.2, 12.0, 12.9, 13.5, 13.8, 13.9, and 15.1 g/min. Respective eating durations were 5.0, 8.1, 12.0, 15.6, 19.1, 21.9, 25.1, and 28.0 min. With increasing meal size, the sheep appears to adjust both eating rate and duration. With larger meals, the eating rate levels off while eating duration continues to increase.

To test the hypothesis that blood lipids act to control food intake, plasma FFA were elevated by heparin treatment in calves. Calves were ad libitum fed a complete ration of 20% chopped hay and 80% concentrate. Although FFA increased 269% with heparin treatment, feed intake was not affected. These results support other ruminant studies which have shown no changes in short-term intake after hormonal induced changes in plasma FFA.

Title: Effects of Grinding and Pelleting on the Nutritive Value of Complete Dairy Rations

Leader: J. C. Derbyshire, Beltsville, Md.

Twenty milking cows were fed a 16% long hay: 84% pelleted concentrate diet to maintain milk production but depress fat test from 3.53 to 2.49%. Cows were randomly assigned to five pelleted diets in 5 x 5 Latin square trials of 28-day periods. Pellets, fed ad lib, consisted of 22.5% wheat straw or 30% each of oat hulls, cottonseed hulls, wheat bran or citrus pulp ground through a 4.8 mm screen and incorporated into the basal pellet. Data on the respective rations were: intake of digestible cellulose ($P < .001$) 1.34, 0.91, 1.13, 0.60 and 1.22 kg; percentage of butterfat ($P < .001$) 3.35, 2.71, 3.33, 2.58 and 3.35; kg FCM ($P < .01$) 16.7, 14.7, 17.0, 14.6 and 16.3 and percentage of SNF ($P < .001$) 9.04, 9.18, 9.06, 9.22 and 9.01. Milk production on all treatments was greater than predicted from a 2% weekly decline but FCM production was less than predicted ($P < .001$) on oat hulls and wheat bran. Ration effects on all milk variables were most closely related to intake of digestible cellulose. There were no consistent relationships between fat test and intake of indigestible acid detergent fiber nor rumen $C_2:C_3$ ratios.

Title: Energy and Protein Utilization in Forages Fed to Dry Cows

Leader: J. B. Holter, New Hampshire

Grass hay cut June 3 and ensiled at 35% dry matter, the same haycrop cut June 15 and conserved as field-cured hay, and urea-treated corn silage were compared on the basis of digestibility, energy utilization and nitrogen utilization in dry cows. Wilted haycrop silage was substantially higher than hay in crude protein, fat, minerals, proximate nutrient digestibility and TDN. Urea-treated corn silage was higher in crude protein than hay, and similar to wilted haycrop silage in proximate nutrient digestibility. Tissue nitrogen and energy balance were highest in urea-corn silage. Wilted haycrop silage (35% DM) is superior to field cured hay as a method of harvesting haycrop.

Title: Energy Value of Feedstuffs for Dairy Cattle

Leaders: P. W. Moe and H. F. Tyrrell, Beltsville, Md.

Data from several experiments indicated that the digestibility and net energy value (NE-milk) were substantially lower than comparable figures listed in commonly used tables of feed composition. Net energy values for the following feedstuffs were (Mcal NE-milk per kg dry matter): U.S. 1 alfalfa hay, 1.18; ground barley grain, 1.87; ground corn grain, 1.98; mature, well-eared corn silage, 1.54; ground oats grain, 1.75; wheat bran, 1.47. Other experiments with flinty and floury endosperm varieties of corn indicated no difference in digestibility at either maintenance intake or with lactating cows when 2.5 kg of the test corn was added to a basal diet of 40% alfalfa hay and 60% concentrate. Other experiments with distillers dried grains and brewers dried grains were delayed because of labor shortages and are currently in progress.

Title: Estimation of Forage Palatability

Leaders: W. A. Kendall, Pasture Research Laboratory, University Park, Pa.

A technique was developed to evaluate the use of meadow voles to estimate the palatability of forages for sheep and cattle. The meadow voles were provided with a constant supply of mouse chow and offered the experimental forages for a 30 min feeding trial at 3 hr intervals. The forages were fed either fresh or oven-dried and ground to pass a 1 mm screen. Forages consisted of 12 clones of reed canarygrass which were known to differ in

alkaloid content and in palatability for sheep; and 6 clones of ryegrass-fescue hybrid derivatives which differed in the content of the alkaloid, perloine. In all feeding trials, a sample of each forage was assayed for alkaloids by Dr. R. T. Sherwood. The intake of reed canarygrass clones was inversely correlated ($r = -0.851^{**}$) to alkaloid content, whereas intake of the ryegrass-fescue hybrid derivatives was not affected by the various levels of perloine obtained in our samples. These results indicate that meadow vole intake, under the conditions stated, may estimate the palatability of forages. Results with canarygrass are compatible with published reports of the palatability of the same clones when evaluated with sheep. Voles were also shown to prefer several legumes (e.g., alfalfa, red clover, birdsfoot trefoil) compared to crownvetch. Vole intake of crownvetch forage was influenced by the amount of BNPA in the forage.

Title: Evaluation of Barley Lines with Surface Cuticle Changes for Penetration of Rumen Fluid

Leaders: J. B. Powell, J. J. Murray, and N. J. Chatterton, USDA, ARS, Beltsville, Md.

We discovered in 1973 by evaluating some 30 lines of barley with surface wax mutations that some of these permitted easy penetration of the cuticle by rumen fluid. If this same characteristic expression occurs in other crop plants similar to its occurrence in barley, then a whole new area of research may develop to select for improved digestibility by selecting surface wax mutations or cuticle defectives. Studies are presently underway to cross these barleys which have differing degrees of cuticle penetration by rumen fluid. If the character is inherited, we expect good progress in the selection of improved digestibility.

Title: Evaluation of Pastures for Dairy Heifers

Leaders: E. M. Kesler and J. B. Washko, Pennsylvania

Two plots each, seeded to Iroquis alfalfa-Pennmeade orchardgrass or Pennmeade alone with four 56 kg/ha applications of nitrogen, were rotationally grazed for a second season. There were three grazings on the alfalfa-orchardgrass, an average of 216 animal grazing days per plot and an average gain of 0.90 kg/day/heifer. Orchardgrass + nitrogen afforded five grazings, 348 grazing days, and 0.95 kg gain. Dry matter yields were 3.97 tons/acre from alfalfa-orchardgrass and 4.41 tons from orchardgrass.

Yearling Holstein heifers grazed permanent pastures continuously at similar stocking rates. Treatments were: (1) pasture only; (2) pasture plus a supplement of 1 kg ground com/day/animal; (3) grazing restricted to 45% of the area, hay removed from 55% in early June, grazing over entire field thereafter. Weight gains over the 168-day grazing period averaged 99.1, 92.6, and 104.5 kg/animal for treatments 1, 2, and 3, respectively. Hay yield, treatment 3, was 2,961 kg/ha, of which 425 kg later was fed back to heifers on treatment 3 when pasturage became sparse.

Title: Feeding Value of Hay Preserved with Ammonium Isobutyrate

Leader: L. S. Bull, Maryland

Haycrop materials prepared by the Agronomy Department are being evaluated. These studies are in progress and indications are that quality of hay is maintained by adding ammonium isobutyrate at levels of 2% or more. A study is in progress to determine the utilization of energy from ammonium isobutyrate fed at graded increments above a basal diet. Respiration calorimetric techniques are being employed.

Title: Feeding Value of Hay Samples Collected on Commercial Farms

Leaders: Barton S. Baker and Doyle E. Harsh, West Virginia

During the fall of 1971, 1972 and 1973 forage samples were collected from hay stored on farms and analyzed for feeding value. This was done in an effort to get information regarding the feeding value of hay actually being consumed by livestock and also to trace changes in forage content with improved forage production practices.

Crude protein content of grass hay being fed on commercial beef farms has ranged from 6 to 11%. The average sample has contained slightly above 8% crude protein. The total digestible nutrients have accounted for approximately 55% of the total dry matter. These values have not changed during the 3 year sampling period although the yields on the farms have increased an average of 34%. Some farms have doubled yields during this 3 year period without appreciable change in protein or TDN.

The mineral content, however, has changed considerably during the 3 year sampling period. In 1971, only 25% of the samples contained 0.20% or less phosphorus whereas in 1973, 43% of the samples contained 0.20% or less. Magnesium has also decreased in the forage during the 3 year sampling period. Magnesium was 0.20 or less in two-thirds of the samples

in 1971 and was below this value in over 90% of the 1973 samples. Other minerals are being examined and weather data are being correlated with mineral content.

Title: Influence of Handling, Storage and Processing Variables on Feed Value of Stored Forages

Leader: H. K. Goering, Beltsville, Md.

Equal portions of each load of first cutting alfalfa (22% CP) were dried either (1) in a hot-air (60-65 C for about 24 hours) drying rack or in a rotating drum, triple pass dehydrator, at (2) 130, (3) 160 or (4) 180 C outlet temperature. The four dried forages were pelleted with 0.6% salt. Four rams weighing approximately 21 kg were fed (86 g/BW ^{.75} kg) in 4 x 4 Latin-square total excreta collection experiment. Dry matter digestibilities were 61, 62, 60, and 55% ($P < .005$). Digestibilities of nitrogen were 69, 68, 66, and 52 ($P < .005$). Nitrogen intakes were similar for all treatments. Mean nitrogen retentions were 6.0, 7.4, 6.9, and 3.9 g/day. Acid-detergent insoluble nitrogen was 6.6, 7.0, 7.3, and 20.4% of the total nitrogen. Twenty wethers and 20 ewes averaging 18 kg were divided into four groups of 10 sheep and fed individually the 4 treatments for 60 days. Mean daily intakes were 104, 95, 104, and 110 g DM BW ^{.75} kg ($P < .05$). Average daily gains were 148, 132, 142, and 123 g. Grams of feed/g gain were 7.5, 7.9, 7.9, and 9.5 ($P < .05$). Alfalfa dehydrated 180 C reduced digestibility, nitrogen retention, and growth.

Samples of dehydrated alfalfa have been collected from selected states in all regions to determine the frequency of occurrence of decreased nitrogen digestibility cause by overheating. Preliminary data indicate that overheating of alfalfa protein during dehydration occurs in a high percent of the samples analyzed. Commercial dehy and sun-cured alfalfa hay fed both in the pelleted and meal form were fed to steers in a replicated 4 x 4 Latin-square to evaluate digestibility and nitrogen retention. Dry matter digestibility was 63.8 and 55.9 for hay and dehy diets. Crude protein digestibility and nitrogen retention was 66%, 23 g/day, and 52%, 16 g/day for hay and dehy diets.

Title: Influence of Moisture Content on Intake

Leader: L. S. Bull, Maryland

Fresh chopped corn was frozen unfermented and subsequently dried for feeding. Moisture levels (treatments) were: 69% (fresh), or 49%, 31%, and 7% (all at 60 C). Moisture level did not affect intake, digestibility,

eating pattern (time/day or dry matter/time). Conclude that moisture per se is not the intake limitation in feeds fed in fresh-cut form.

Title: The Meadow Vole as a Bioassay of Crop Quality

Leaders: J. S. Shenk and R. F. Barnes, Pennsylvania and Pasture Research Laboratory, University Park, Pa.

A colony of meadow voles (Microtus pennsylvanicus) was established to determine the potential of this animal as a laboratory bioassay of the nutritive value of plant material. To determine the protein and energy requirements of the weanling fed entirely plant material, diets were formulated from orchardgrass, corn, oats, and soybean meal. Diets ranged from 11-33% protein (P) and 20-48% cell wall constituents (NDF). A mathematical model (P-NDF) was derived with these data and other published and unpublished data from alfalfa feeding trials that explain 85% of the variation in weight gain response from the percentage of P and CWC concentration of the diet. The model represents the optimum growth potential of the weanling vole to all practical levels of plant protein and energy in the diet. From the results of prior studies and the quantitative information from the P-CWC model, it became apparent that the weanling vole had the potential to assess the growth promoting properties of the energy and protein composition of plant material as well as the capacity to detect unpalatable or toxic constituents as has been demonstrated with crownvetch forage.

Adult meadow voles were used to obtain estimates of the palatability of fresh and dry forages and certain chemical constituents of forages. Voles used in these tests were provided with a supply of a commercial mouse chow and water at all times. The experimental materials were offered for a 30 min feeding period with intervals of at least 3 hr between feedings. Intake during the 30 min periods, as calculated from changes in weight measurements, was used as a criterion of palatability. Our studies indicate that palatability estimates obtained with meadow voles are comparable to those obtained with sheep for certain clones of reed canarygrass and orchardgrass but not for fescue grass.

Title: Mineral Composition Studies

Leaders: G. A. Jung and C. F. Gross, Pasture Research Laboratory, University Park, Pa.; and R. L. Reid, West Virginia

Magnesium studies revealed that (a) forage species and cultivars differ in Mg accumulation, (b) temperature and growth stage affect Mg concen-

tration and some grasses are affected more than others, (c) forage species respond differently to Mg fertilization, (d) marked increases in Mg were observed in some pasture grasses fertilized with Emjeo at 100 kg Mg/ha, (e) Mg accumulation is a heritable trait in alfalfa (Cooperative studies with R. R. Hill, Jr.), (f) ruminant absorption of Mg from forage was found to be very different for several forages and depended on plant species, plant growth stage, and Mg fertilization. Excretion of Mg in urine was particularly high for tall fescue.

Title: Mineral Composition and Mineral Availability in Forage Crops, with Particular Reference to Magnesium and the Grass Tetany Syndrome

Leaders: R. L. Reid and J. A. Balasko, West Virginia; G. A. Jung, Pasture Research Laboratory, University Park, Pa.

A cooperative project between the USDA and West Virginia on factors affecting Mg composition and utilization of forage crops was initiated in 1973. Various grass and legume species were harvested at different growth stages, with or without Mg fertilization, and analyzed for Mg and other elements. In addition, hay cuttings (first growth and regrowth) were made and fed at controlled intake to lambs in mineral balance trials. Analytical data have indicated a variable response in Mg composition to Mg fertilization (source was 80% MgSO_4 , at 112 kg/ha); an increase, where obtained, was noted mainly at the earlier growth stages and had essentially disappeared at the hay cutting stage. However, differences in Mg availability and retention due to forage species, cutting and Mg fertilization were obtained in balance trials with the growing lamb.

Trials to examine various approaches to control spring tetany were begun in 1974. Twenty-four beef cows and calves were maintained from January-April on hay supplemented with a self-steamed bone meal-MgO mixture. In April, cows were turned on to replicated orchardgrass pastures under three treatments: (1) high N-high K fertilization; (2) same, + fertilization with MgSO_4 at rate of 168 kg Mg/ha; (3) same, supplemented with Mg concentrate blocks. Blood samples were taken before and for a 2-3 week period after turning cows on pasture, and serum and herbage samples are being analyzed for changes in mineral composition.

Title: Nutrition Requirements of Pregnant and Lactating Ewes and Their Lambs

Leader: I. L. Lindahl, Beltsville, Md.

Two groups of 20 ewes maintained for reproduction were fed either a diet containing 75 to 95% dehydrated cattle manure (I) or a diet containing 80 to 100% alfalfa (II) during breeding and gestation. Conception and maintenance of pregnancy for the first 90 days of gestation were similar for the two groups. However, abortions after 90 days of gestation, lambs born dead and early lamb mortality were marked in ewes receiving ration II; 5 lambs were alive at 2 weeks after lambing from ewes receiving ration II compared with 20 ewes receiving ration I. Retained placentas also were a problem with ewes receiving ration II. Incomplete results of similar feeding trials in 1973-1974 indicate that adjustment of the energy and P levels in the diet containing dehydrated cattle manure markedly improved the lambing performance. The infusion of 20 liters of water into the rumen of cattle fed either a hay or a hay-concentrate ration at slightly above maintenance level of intake results in a decreased rumen VFA concentration and a reduced osmolarity of rumen fluid of about 1/4 of that expected from the change of rumen VFA concentration. Evidently some metabolite moves from tissue to rumen fluid to maintain osmolarity. Neither dehydrated alfalfa meal treated with 0.33, 0.67 or 1.00% formaldehyde or dehulled soybean meal treated with 0.6% formaldehyde, when used as the major source of supplemental protein in high concentrate rations for growing-finishing lambs affected rate or efficiency of gain. The result with the treated dehydrated alfalfa meal is in contradiction to results reported in FY 1973, and that with treated soybean meal results published in the scientific literature. The cause of these discrepancies has not been found.

Title: The Evaluation of Organic Acids for the Preservation of High Moisture Aerobically Stored Forages

Leaders: N. A. Clark and C. C. Sheaffer, Maryland

Propionic acid and ammonium isobutyrate were applied to aerobically stored forages with a moisture content ranging from 21 to 52% in order to prevent mold growth. The organic acids were manually applied to chopped and baled alfalfa-timothy hay at the following rates: 0, 1.00, 1.50, 1.75, 2.00, 3.00, 4.00, and 5.00%. Temperatures were monitored throughout the storage periods. The following factors were determined by chemical analyses: in vitro dry matter digestibility, acid detergent fiber, acid detergent insoluble nitrogen, and total nitrogen.

There was no significant difference in the preserving abilities of the two organic acids, but hay to which ammonium isobutyrate was applied has a

higher nitrogen content than the untreated hay or hay to which propionic acid was applied. Ammonium isobutyrate was found to be less corrosive than propionic acid.

Moisture was the most important factor influencing the effectiveness of a particular rate of application in preserving the forage. Hay stored at a moisture content exceeding 35% required higher rates of organic acid to prevent molding, while hay with a moisture content below 35% was preserved with lower rates of organic acid. Chopped hay required increased rates of acid to prevent molding when stored at a similar moisture as the baled hay.

Title: Protein and Nonprotein Utilization by Ruminants

Leaders: R. R. Oltjen and D. A. Dinius, Beltsville, Md.

Considerable time has been spent developing expertise in operating the new N¹⁵ equipment. In vitro experiments have been conducted in cooperation with the Microbiology Laboratory and will be reported by that group.

Cattle were fed a low-quality forage diet and a nitrogen-mineral supplement. The nitrogen component was the variable, being urea, biuret, fishmeal or combinations of these. The cattle consumed insufficient quantities of the supplement unless corn meal was added. However, even when the desired level of consumption was achieved, the nitrogen was poorly utilized, the cattle lost weight, and the experiment was terminated prematurely.

Title: Forage Soluble N Effects on Cellulose Digestion and NH₃ Production by Rumen Microorganisms

Leaders: W. P. Apgar and R. E. Goodnow, Maine

The study described in the 1972 Annual Report (p. 67-68) is being continued with additional varieties and numbers of forage samples.

Title: Studies on Allelochemical Properties of Crownvetch and Their Effect on Forage Quality

Leaders: D. L. Gustine and R. F. Barnes, Pasture Research Laboratory, University Park, Pa.; and J. S. Shenk, Pennsylvania

Compounds were isolated from fresh-cut oven-dried crownvetch forage that cause death to meadow voles, chicks, and pigs. They were isolated by the procedure described previously (Annual Report, 1971, p. 60; 1972, p. 55), except that silicic acid column chromatography was used instead of preparative thin-layer chromatography. One fraction contained two compounds (72 mg) identified as β -nitropropionic acid (BNPA) and ethyl β -nitropropionate. Other fractions contained six compounds (929 mg) that were shown to be glucose esters of BNPA. Mixtures of esters fed to weanling voles and day-old chicks were shown to be toxic. When BNPA (purchased from Aldrich Chemical Co.) was fed to voles, chicks and young growing pigs, it was found to be toxic to all three animal species. These compounds were not fed to ruminants, but crownvetch known to contain BNPA or its esters at levels of 2%, while toxic to voles and chicks, was not toxic to sheep.

A colorimetric procedure for determining aliphatic nitro compounds in forages was modified for testing small forage samples (0.1 g or more), and used for determining the levels of BNPA in different crownvetch forage samples. The levels ranged from 0.3% to 3.5% in fresh forage. Field-cured forage contained less than 0.3%; wagon-dried forage contained 0.6-0.9%. Crownvetch plants collected in the field, frozen in liquid nitrogen and freeze-dried contained as follows: stems, 1.3% leaves, 3.5%; flowers 5.2% (air dried, not frozen).

Title: Utilization of Digestible Energy in Cattle

Leaders: H. F. Tyrrell and P. W. Moe, Beltsville, Md.

During the year two 14 week infusion experiments were completed in an attempt to make quantitative measurements on the efficiency of utilization of absorbed acetate by nonlactating dairy cows. Intra-ruminal infusion of acetic acid at a rate of from 10 to 20% of metabolizable energy intake generally decreased digestibility of dry matter and energy, decreased methane production and increased heat production. The effect of acetic acid infusion upon digestibility of the basal ration makes the quantitative estimation of efficiency of utilization of acetic acid impossible. It was demonstrated that disruption of feed intake by acid infusion was preceded by acidosis as measured by blood pH and pCO_2 . Digestibility was depressed when no measurable acidosis occurred,

however. Repeated samples obtained from the rumen of one cow indicate that infusion of 20 liters of water per day decreases the buffering capacity of the rumen ingesta and may predispose the cow to more rapid development of acidosis and disruption of normal function when acetic acid infusion follows water infusion. Glacial acetic acid in the amount of 700 g per day has been infused undiluted into the rumen of one cow continuously and has not disrupted rumen function to the extent water infusion other than to increase markedly rumen acetate concentration. These experiments emphasize that results of infusion experiments conducted nearly 20 years ago with sheep may not be applicable to cattle.

SECTION IX

SILAGE RESEARCH

Title: Formic Acid as an Additive to Forage for Ensiling

Leaders: D. R. Waldo and J. C. Derbyshire, USDA-ARS, Beltsville, Md.

When comparing silages producing poor heifer daily growth to those producing good heifer daily growth the digestibility is similar, energy intake is reduced somewhat but the efficiency of energy utilization for growth is reduced the most. The silages producing poor daily gains usually suffer greater storage losses so that gain per acre is further reduced. Paraformaldehyde addition at ensiling seems as effective as formic acid in preventing this poor performance and at 1/5 the cost. Feeding supplemental formaldehyde treated soybean meal suggests that the protein poor silages is so degraded as to be the major limiting nutrient.

Title: Oxygen Disappearance from Alfalfa Forage in Silage

Leader: M. A. Sprague, New Jersey

Data from several years experiments were evaluated relative to oxygen disappearance in silage. Chopped alfalfa forage was sealed in one ton plastic silos immediately after cutting. Up to 90% of the atmospheric oxygen was lost in the first 15 minutes and less than 1% remained after 30 minutes from the time of sealing. These rates of loss, compared with earlier studies of hydrolyzable carbohydrate losses during drying in the swath, confirm a very high rate of respiration in live tissue at the time of cutting. Loss of oxygen was more rapid from direct-cut forage than from partially dried suggesting that respiration continues after cutting until individual cells die. Application of a vacuum for removal of oxygen from silos in silage-making is impractical.

Title: Associative Feeding Effects Between Urea-Treated Corn Silage and Wilted Haycrop Silage in Dairy Heifers and Lactating Cows

Leader: J. B. Holter, New Hampshire

Heifers were fed forages only and lactating cows were fed concentrate plus forages. Forage treatments were urea-treated corn silage (12% crude protein, 23% dry matter) and wilted grass haycrop silage (12% crude protein, 45% dry matter) in dry matter ratios of: 100:0, 67:33, 33:67, and 0:100. Diets were compared on the basis of proximate nutrient digestibility and efficiency of use of dietary energy and nitrogen. To evaluate possible associative effects, animal response to mixed forage treatments was compared with animal response predicted from single forage diets. No significant positive associative feeding effects were found in heifers or lactating cows.

Title: Corn Silage with Either Haycrop Silage or Hay for Lactating Cows

Leader: J. B. Holter, New Hampshire

Eight Holstein cows were fed concentrate to production plus forage composed of 60% (DM basis) urea-treated corn silage and 40% grass haycrop either as field-cured hay or as wilted (37% DM) silage. Proximate nutrient digestibility, and efficiency of use of energy and nitrogen of diets were compared at 6 and 21 wk postpartum. Nutrient digestibility and efficiency of use of gross energy and dietary nitrogen were not affected by method of haycrop harvest. No significant forage treatment-by-stage of lactation interactions were found. It was concluded that the advantages of wilted haycrop silage over hay are early harvest with less weather risk and adaptability to mechanized harvest and feeding.

Title: Effect of Urea Supplementation to All Corn Silage on Cow's Rumen Fermentation

Leader: H. Fenner, Massachusetts

In a 4 x 4 Latin square feeding trial with dry, fistulated Holstein cows a ration of corn silage offered at constant intake was supplemented with 0, 90, 180, and 270 g of urea by combining both just prior to feeding in portions of 1/3 and 2/3 corresponding to the time intervals between morning and evening meals. As parameters of changes in rumen fermentation

as a result from the urea supplementation served water consumption, pH and concentration changes of organic and dissolved inorganic rumen fluid constituents. Increased urea supplementation significantly raised the pH in the rumen fluid, and more than tripled the ammonia level. There was also a significant lowering of the isobutyric and n-valeric acid proportion in the total acid fraction. Also linear decreases in the concentration of dissolved calcium and magnesium occurred as a direct response to the urea supplementation. Water intake was lowest with the ration of lowest level of urea supplementation followed by the unsupplemented ration and then paralleling the level of urea supplementation, similar to the pattern of water consumption established previously with potassium carbonate. The base supplementation was partly used to neutralize the acidity of the silage which otherwise was compensated for by an increased water intake. Animals on the highest urea intake (total crude protein level 18.2% and 75.1% total NPN) showed stress symptoms to use their extremities during the end of the 28 day trials. Digestibility of the ration was assumed to be unaffected by the urea supplementation.

Title: Feeding Pellets made from the Whole Corn Plant to Lactating Cows

Leader: J. H. Vandersall, Maryland

Twenty-four Holstein cows were blocked into six groups for a 12 week experiment, and randomly assigned to one of the following forage diets: Corn silage only; 1:2 pellet to silage ratio (dry-matter basis), 2:1 pellet to silage ratio; pellets only. Forages were fed ad libitum and a 28% protein concentrate was fed to all cows to provide 2.3 times the amount of protein in the milk. There were no significant differences in milk production. The cows fed pellets only had a significant depression in fat percentage, but there were no differences among groups in protein percentage nor protein production. Total dry matter intake was greater for the cows fed both forages than when either was fed separately. Forage dry matter was significantly higher for those receiving 2/3 of their forage as pellets than for the other groups. Body weight changes were not significantly different among groups.

Title: Sunflower Silage for Dairy Cows

Leader: J. H. Vandersall, Maryland

Previous work indicated that cows fed sunflower silage did not maintain milk production as well as those fed corn silage when concentrates were fed on the basis of a 3:1 milk-concentrate ratio. An experiment has just been completed where cows fed sunflower silage ad lib., and a milk-concentrate ratio of either 2:1 or 3:1 were compared to those fed alfalfa hay and corn silage and a milk-concentrate ratio of 3:1. All cows did reasonably well on each of the three diets. The data are being summarized at the present time, and will soon be available.

SECTION X

ENVIRONMENTAL RESEARCH

Title: An Investigation of Seasonal Pb Levels of Tall Fescue as Related to Tissue Pb Concentration and Red Blood Cell Parameters of Voles

Leader: D. J. Horvath, West Virginia

The main objective of this study was to investigate the possible effects of recycling various materials on crop or grazing land upon animals. The entry of Pb into meadow vole (Microtus pennsylvanicus) tissues as a result of feeding tall fescue treated with various levels of sewage sludge was proposed. However, higher Pb forage levels were attributed to seasonal Pb increases in the dormant fescue rather than the recycling of sewage sludge, even at rates of 100 T/A of sludge.

To investigate differences in tissue Pb concentrations and red blood cell parameters as related to seasonal Pb differences in tall fescue, three semipurified diets, composed of 40% summer-cut fescue (SF), 40% summer-cut fescue plus added Pb acetate (SF + Pb Ac), and 40% winter-cut fescue (WF), containing 4, 14, and 14 ppm Pb respectively, were fed to weanling voles for 30 days. The feeding of the high Pb diet elevated ($P < .01$) vole liver, kidney, tibia, and femur Pb concentrations as compared to the low Pb diet. The elevation of tissue Pb represents a 79%, 78%, 83%, and 61% increase for those tissues respectively. Voles receiving high Pb diets had 15% lower hematocrits ($P < .01$) and 9% lower hemoglobin ($P < .10$) than those fed the low Pb diet. The naturally-occurring Pb in diet WF was more effective in increasing liver ($P < .05$) and kidney ($P < .10$) Pb and depressing hematocrit ($P < .10$) and hemoglobin ($P > .10$) than the Pb added as acetate. However, the greatest increases in tibia ($P < .05$) and femur ($P < .10$) Pb were due to the added Pb in diet SF + Pb Ac. The depression of blood parameters due to seasonal Pb elevation has been observed in an unfinished follow-up study utilizing a different fescue source.

The tissue Pb increases observed do not approach frank toxic levels but the relationship between the incidence of swayback in lambs and Pb content of pasture grass suggested by Allaway (cited in Klauder et al., 1972. Trace Substances in Envir. Health VI. University of Missouri) would justify consideration of the seasonal variation of Pb in respect to the mineral status of livestock grazing winter pastures.

Title: Contribution of Animal Wastes to Plant and Soil Characteristics

Leaders: L. E. Chase, T. A. Long, H. D. Bartlett, and L. F. Marriott,
Pennsylvania

Subsurface application of liquid dairy manure was made on 20 x 50-foot test plots of Hagerstown silt loam soil seeded with orchardgrass. The treatment rates were equivalent to 0, 700, 1400, 2100, 2800, and 3500 pounds of total nitrogen per acre (0, 15, 30, 45, 60, and 75 tons DM/acre). Manure was applied in 1969, 1970, and 1971. No manure was applied in 1972 and 1973. Three cuttings of orchardgrass were removed in 1971 and two cuttings in 1973. Suction lysimeters were also installed in each plot of depths of 1, 2, 3, and 4 feet to allow soil water samples to be obtained. Data presented here are for the 1971 samples and in the case of the orchardgrass, represents the average of the three cuttings.

The total protein content of the orchardgrass was 11.26, 17.13, 18.80, 18.92, 18.50, and 18.44%, respectively with increasing level of manure applications. The mean plant nitrate-nitrogen levels were 645, 1544, 2169, 2347, 2272, and 1974 ppm. Plant yields (tons DM/acre) were 0.83, 2.61, 2.86, 2.47, 2.35, and 2.42. The average soil water nitrate-nitrogen concentrations were 7, 13, 30, 38, 51, and 67 mg/liter from samples taken in November of 1971. The samples taken in 1973 are currently being evaluated for possible carryover effects.

Title: Disposal and Utilization of Dairy and Poultry Manure by Land Application

Leaders: J. L. McIntosh, T. A. Ranney and K. E. Varney, Vermont

Plots established and continued since 1965 (see 1972 Annual Report, p. 75) to study the effect of annual applications of N and manure treatments on clay soil and continuous corn were continued this year. The modification initiated last year, banding application of K at 3 rates, were maintained this year. Soil and leaf samples were analyzed and corn yields measured.

Plots established to compare the immediate and accumulative effects of three rates of manure (0, 33, and 66 tons/ha) with mineral fertilizers applied at rates calculated to provide levels of N, P, and K comparable to those in the manure treatments were continued. Soil and leaf samples were analyzed and corn yields measured.

Cultivation and cropping for 5 years on the check plots reduced organic matter; (by N) 8.7% and OM (by C) 17.7 %. An annual application of 44 tons/ha of fresh dairy cattle manure was needed to maintain soil OM. CEC was increased by manure treatments as would be expected from increase in soil OM.

Soil test results (pH 4.8, NH_4OAc extractions) showed that P from manure was more available than fertilizer P; 119 kg/ha of P from manure increased soil test P about the same as 480 kg/ha of P from fertilizer. However, K, either from manure or fertilizer, was readily fixed by the soil (60 to 75% of the applied). More than 414 kg/ha of K was needed to bring K potential in soil to the -3,500 calorie level suggested as adequate for standard free energy of exchange of K for Ca and Mg.

Manure application up to 44 tons/ha did not contain enough Ca or Mg to maintain initial levels in the soil. Manure and N treatments had no measurable effects on Fe and Na levels in the soil. Averaged over all treatments, exchangeable Na decreased from 123 to 85 kg/ha and Mn from 45 to 20 kg/ha during the 5 years (1966 to 1971). Treatments of N did not affect rate of breakdown of OM nor decrease pH. The highest rate of N, compared to check plots, slightly increased Mn extracted (by 6 kg/ha). The highest rate of manure decreased extractable Mn (8 kg/ha) and Al (5 kg/ha).

These data showed the value of fresh manure as a soil amendment in addition to its nutrient content. Land applications of manure should be encouraged as a method of disposal but its agronomic value emphasized to encourage use with a minimum of loss.

Title: Disposal and Utilization of Dairy and Poultry Manure by Land Application

Leaders: H. D. Bartlett and L. F. Marriott, Pennsylvania

Water samples from suction lysimeters, soil samples and dry matter yields were continued on replicated plots receiving subsurface treatments of liquid manure from dairy cows on an established seeding of Pennmead orchardgrass for three consecutive years (1969-1971) at annual rates of 700, 1400, 2100, and 3500 lb. N/acre. The same determinations were made on replicated plots of a Kentucky bluegrass seeding to which subsurface treatments of liquid manure were applied in May, 1973 at rates of 280, 370, and 460 lb. N/acre, plus a check treatment of 100 lb. N as urea. Also, manure was injected between rows of replicated corn plots at rates of 200, 300, and 400 lb. N/acre, in addition to 100 lb. N as urea over all treatments. Soil samples were taken to 4 ft depth of all plots for determination of N, NO_3 , Ca, Mg, K, Na and Cl. Forage from the respective treatments was ensiled for nutrient quality analysis and acceptability with sheep (orchardgrass only).

Nitrate levels in soil water samples from the orchardgrass plots remained well above 10 mg/liter at the 3 ft and 4 ft depths for the four higher manure rates. Dry matter yield reflected declining nitrogen availability at the lowest rate. Corn silage yields were significantly increased by the manure treatments (3.7 T/acre to 5.2 T/acre). There was no significant difference between manure treatments. Nitrogen levels in the bluegrass forage and corn silage did not differ due to treatment.

Bluegrass plots showed increased nitrate levels in water samples at the 1 ft depth only. Bluegrass yields were not substantially different for the respective treatments.

Title: Disposal of Oxidized Poultry Manure in Soil

Leaders: B. I. Tubea, and R. W. Wengel, Connecticut (Storrs)

For complete denitrification of oxidized manure to occur additional carbon was needed as an energy source. High ammonium-nitrogen concentrations and salt concentrations from fresh manure applications were deleterious to plant growth at rates greater than 10 T/acre. The use of oxidized manure at the same rates did not result in high ammonium levels in soil and no plant damage was noted. Salt concentrations were also lower with oxidized manure than with fresh manure. Higher rates (40 and 80 T/acre) of oxidized manure application have the advantage over higher rates (40 and 80 T/acre) of fresh manure application for manure disposal in that soil nitrate levels were much lower and thus potential pollution problems would be minimized. Yields of perennial ryegrass increased in a direct proportion to rates of oxidized poultry manure applied but were adversely affected by applications of fresh poultry manure at rates greater than 10 T/acre. The potential toxicity levels of plant tissue nitrates were higher in fresh manure treatments than those of oxidized manure treatments.

Title: The Effect of Sewage Effluent on Soil Chemical and Physical Properties and Various Plant Species

Leaders: J. L. McIntosh, T. A. Ranney, F. R. Magdoff and R. J. Villamil, Vermont

Sewage lagoon water collected from Button Bay State Park was sprayed onto a clay soil during the summer and fall of 1973. Data from one field season at the Button Bay Spray Irrigation System indicate that the size of the system was great enough so that all of the liquid effluent generated at the park could be accepted by the soil. No adverse effect was noted on either soil chemical or physical properties. Nutrient contamination of ground water below the spray site was minimal or non-existent. The nitrate content of the lagoon water was very low to begin with and uptake by plants, denitrification and dilution in the soil water were probably responsible for the extremely low NO₃ levels in the soil during and after spraying. The concentrations or potentially toxic heavy metals in the lagoon water were below detection levels.

No adverse effect of the spray treatment on plant development or nutrient content was observed. The only effect observed was a large stimulation of plant growth in the spray area.

One factor yet to be determined is the optimal loading rate permissible for a given soil moisture content so that significant runoff may be avoided. This is currently being investigated.

Title: Effects of Sewage Sludge on Soils and Yield of Soybeans and Corn

Leaders: A. M. Decker, J. M. Walker, and R. L. Chaney, Maryland

Corn and soybeans were grown for the second season on soils that had received 0, 25, 50, and 100 dry T/acre of digested sewage sludge. Half of the sludge treatments were fertilized, while the other half were unfertilized. Data being collected are: (1) yields of beans, corn grain, and corn silage; (2) nutrient status of the soil (including heavy metals); (3) chemical composition of plants grown on the various treatments; and (4) the effects of feeding corn silage and grain to animals.

Corn grain yields were increased from 58 to 171 bu/acre, silage from 9.4 to 23.6 T/acre, and soybean from 37 to 56 bu/acre by the addition of sludge. The application of fertilizer had little effect on yield except on the non-sludged plots.

Marked changes in soil nutrient status and soil tilth resulted from sludge applications. Heavy metals increased in the soil and these were taken up by the plants, but data are too preliminary to be conclusive at this time.

Title: Land Disposal of Sewage Sludge (Agronomic Aspect)

Leaders: R. W. Duell, R. B. Alderfer and R. L. Flannery, New Jersey

Sites typifying Lakewood, Woodmansie and Downer soils were cleared of native "pine barrens" vegetation and each was planted to three one-quarter acre plots of "Midland" bermudagrass. Plots treated with municipal sewage sludge at 10, 20 and 40 T/acre established well. K, Ca, Mg, Mn, Fe, Cu, and Zn varied but were within normal ranges for grass tissue contents. Dry matter yields generally increased with sludge rate, as did N and P contents of tissue. No injury to bermudagrass foliage was evident, but scalding of leaves of oaks receiving similar treatments was obvious. Quarter-acre plots are also being monitored for groundwater quality. Smaller plots receiving only minimal inorganic fertilization serve as base-status controls for Midland bermudagrass analyses.

Preliminary investigations of what happens following application of waste-water solids on recently tilled bare soil surface indicate that most solids remain on the surface in amounts sufficient to impede absorption of the liquid fraction due to clogging of pores in the upper centimeter of surface soil. Time required for disappearance of the liquid fraction into Lakewood and Woodmansie soils was 45 and 23 minutes or an infiltration rate of 2.6 and 1.33 cm/hr, respectively. Application of another cm to the moist solids-coated surface immediately after disappearance of the liquid fraction of the first application resulted in a very marked reduction in liquid absorption rate, namely .27 and .42 cm/hr on Lakewood and Woodmansie soils, respectively. Accumulation of a similar surface coating or cake of solids is readily observable in the bermudagrass plots and on litter in wooded plots.

Measurements of the water retention characteristics of the 0-3 and 3-6 inch layers of each soil type reveal that the physical effects of one year of sewage sludge treatments are confined to the upper three inches of the surface soil under bermudagrass as well as under natural woodland vegetation (pitch pine, scrub oak and blueberry). Increasing rates of sewage sludge application increased the water retentive capacity, particularly that held at suctions of 0.06 and 0.10 bars; and decreased the hydraulic conductivity rates of these very sandy outer Atlantic Coastal Plain soils. This is due primarily to the effects of the filling of the small near-capillary sized pores by organic solids sufficiently to be reflected in a rather large and consistent increase in the amount of water able to be held at suctions less than .33 and 1.0 bars. Pore-filling markedly decreased rate of water movement compared with the untreated soil under both bermudagrass and native forest vegetation. This lowered the water intake and transmission rate from a very high 5+ inches/hr to a moderate .75 inch/hr rate in recently (1972-73) cleared soils planted to bermudagrass in June 1973 and from 14 to 7 inches an hour in the 3-inch A₁ horizons under the forest litter.

Title: Utilization of Plant and Animal Waste Products and of Forage by Beef Cattle

Leader: D. A. Dinius, USDA-ARS, Beltsville, Maryland

Pregnant beef heifers were fed a diet containing 50% waste wood pulp fines for 99 days and gained 50% more weight than heifers fed a control forage diet. The pulp fed heifers were subsequently fed a diet containing 75% wood fines for another 209 days and gained weight at the same rate as those fed the control diet. The heifers delivered calves during this latter experiment. There were no abnormal calves; calves born to heifers fed pulp fines tended to be larger than those born to control heifers.

Sawdust was again fed as a nondigestible diluent in a concentrate diet to inhibit cattle from overeating when initially offered concentrate ad libitum. The cattle had been fed a forage diet and then were placed in feedlots and immediately offered concentrates diluted with 35% sawdust for 5 or 10 days; the sawdust was then withdrawn and the cattle continued on the all-concentrate diet. Steers fed sawdust for 10 days had fewer off-feed problems than those fed sawdust for 5 days, but cattle gradually shifted from forage to grain tended to out-perform those shifted by feeding sawdust.

Title: Utilization of Waste Water

Leaders: G. A. Pearson, USDA-ARS, Georgetown, Delaware and G. A. Jung, Pasture Research Laboratory, University Park, Pa.

Utilization of waste water from the food-processing industry, for beef production was evaluated in Delaware. With little additional fertilizer and a 1% (body weight) grain supplement, heifers gained 728 kg/ha in 140 days.

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RECIPIENTS OF GRADUATE DEGREES - 1973

M.S. Degree

Name	Institution	Advisor	Thesis Title
Alt, Freddie L.	W. Virginia Univ.	J. A. Balasko G. A. Jung	Effect of time and rate of nitrogen application on the yield and chemical composition of six forage grasses.
Bruetsch, T. F.	Univ. New Hampshire		Genotypic variation in nutrient uptake efficiency and its physiological importance in maize.
Dest, W. M.	Univ. Connecticut	D. W. Allinson	The influence of cultural techniques and soil properties on the growth and development of annual bluegrass (<u>Poa annua</u> L.)
Gallo, Thomas S.	W. Virginia Univ.	Linda Butler	Parasites affecting the alfalfa weevil, <u>Hypera postica</u> (Gyll.)
Helsel, Zane R.	Penn. State Univ.	J. S. Shenk	Forage quality and morphological characteristics of orchardgrass (<u>Dactylis glomerata</u> L.) clones.
Johns, William III	Univ. New Hampshire	J. B. Holter	Associative effects between urea-treated corn silage and wilted haycrop silage in heifers and lactating cows.
Kalmbacher, R. S.	Penn. State Univ.	J. B. Washko	Forage management practices for woodland clearings for deer.
Meeks, Lawrence E.	Univ. Maryland	N. A. Clark	Effects of flaming on the growth and quality of alfalfa.
Moyer, B. G.	Penn. State Univ.	K. T. Leath	Substitution for the ultraviolet light requirement for sporulation in <u>Leptosphaerulina briosiana</u> (Poll.) Graham and Luttrell.

<u>Name</u>	<u>Institution</u>	<u>Advisor</u>	<u>Thesis Title</u>
Palazzo, A. J.	Rutgers Univ.	R. W. Duell	The response of turfgrasses to soil pH, and high Mn concentrations.
Rosen, Morris	W. Virginia Univ.	J. A. Balasko	Effects of plant density and nitrogen fertilization on the growth and chemical composition of timothy (<u>Phleum pratense</u> L.)
Triolo, A. C.	Univ. Connecticut	R. A. Peters	Influence of organic matter and mulch on effectiveness of alachlor in no-tillage corn.
Tubea, B. I.	Univ. Connecticut	R. W. Wengel	Disposal of oxidized poultry manure in soil.
<u>Ph.D. Degree</u>			
Baluch, S. J.	Penn. State Univ.	M. L. Risius	Estimates of genetic variance in <u>Coronilla varia</u> L. cv. 'Chemung.'
Daddario, J. J.	Rutgers Univ.	M. A. Sprague	A physical and biological evaluation of microclimate induced by 40° North- and South-facing microclimates at New Brunswick, New Jersey.
Desai, S. N.	Penn. State Univ.	J. B. Washko	Forage evaluation of four summer annuals at four harvest stages under different nitrogen levels.
Faix, J. J.	Cornell Univ.	M. J. Wright	The effect of temperature and daylength on the quality of morphological components of three legumes.
Obuama, A. T.	Univ. Massachusetts	L. F. Whitney	Mechanical parameters in leaf cell membrane rupture for protein extraction.

Name	Institution	Advisor	Thesis Title
Prigge, E. C.	Univ. Maine	W. P. Apgar	Effects of the soluble nitrogen composition on the utilization of forages by ruminants.
Ratcliffe, R. H.	Univ. Maryland	A. L. Steinhauer	The role of larval antibiosis in the expression of resistance in alfalfa to the alfalfa weevil.
Schroder, R.F.W.	Univ. Maryland	A. L. Steinhauer	A comparative study of alfalfa weevil populations from the United States and Europe.

